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An analysis of environmental data for use in updating low frequency propagation loss forecasts.

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AN ANALYSIS OF ENVIRONMENTAL DATA FOR USE IN UPDATING LOW FREQUENCY PROPAGATION LOSS FORECASTS

Phillip Ivan Harvey

An Analysis of Environmental Data
for Use in Updating
Low Frequency Propagation Loss Forecasts

by

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ABSTRACT

An acoustic model for low frequency(100-2400 HZ) propagation loss within a surface duct is examined. An analysis of the sensitivity of this model as a function of the governing environmental parameters is performed. The results of this analysis show that the frequency and mixed layer depth are influential over a wide range of environmental conditions and that the below layer thermal gradient becomes important at low frequencies when the layer depth is relatively shallow. Under certain conditions, a change in below layer thermal gradient of 2°F/100 FT has the same resultant effect as a 25 FT change in the mixed layer depth. The results of this analysis are then utilized to develop a correction algorithm which can be employed to update propagation loss forecasts (issued by Fleet Numerical Weather Central, Monterey) when required due to changing environmental conditions.

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I. INTRODUCTION

The Acoustic Sensor Range Prediction (ASRAP) program (NAVWEASERVCOMINST, 3160.3, 1971) is currently conducted under the direction of Commander, Naval Weather Service Command and provides computer generated range predictions which are utilized primarily for airborne acoustic sensors. These sensor systems, the passive JEZEBEL system and the active systems of JULIE and active sonobuoys, are dependent upon accurate environmental data forecast through the ASRAP program. These ASRAP forecasts consist of two general parts, an active portion and a passive portion. This discussion will be limited to the passive part of the forecast. Passive propagation loss forecasts are provided on a weekly basis for most ocean regions in the northern hemisphere.

Prior to generating a forecast, the ocean has been divided into regions which have similar acoustic characteristics of sound velocity profile, bottom type, and bottom depth. For example, a near-shore region may consist of a sound velocity profile which is subject to short-term fluctuations due to temperature perturbations, a sandy type bottom, and a relatively shallow depth. In contrast, an open ocean region could consist of a sound velocity profile which has long-term seasonal fluctuations due to temperature changes, a bottom composed of ooze type material, and a relatively deep bottom depth.

Once these acoustically homogeneous provinces or domains, termed ASRAP areas, have been defined, the propagation loss for discrete frequencies of 50, 300, 850, and 1700 Hertz is determined. This loss is calculated for three distinct cases: (1) Shallow-Shallow where the sonobuoy hydrophone is placed at 60 feet and the target source is also at 60 feet, (2) Deep-Deep where the hydrophone is at 300 feet and the target is 200 feet below the mixed layer depth (MLD),[1] and (3) Cross-Layer wherein sonic energy crosses the mixed layer. The hydrophone is at 60 feet and the target is 200 feet below the MLD for this case.

The manner in which this loss is determined or calculated is dependent to a large degree upon the environmental parameters of layer depth and the below layer thermal gradient. If these parameters allow for the transmission of sonic energy from source to receiver via a sonic duct formed between the surface and MLD, the amount of loss encountered can be determined analytically. The analytical method is employed out to a range at which multiple path transmission via bottom reflection and convergence zone paths have a significant effect. Beyond this range, a geometrically solved ray-trace routine is utilized. On the other hand, if no sonic duct is present, then the loss is calculated for the entire field by the ray-trace routine.

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[1] Mixed Layer Depth is defined as that depth near the surface where the sound velocity reaches a maximum value.

The objective of this thesis is to develop a method by which a fleet user of ASRAP forecasts can update the forecast propagation loss by applying current environmental data available. This method is desirable since, due to the large number of areas which must be processed (over 1000), and the time required to compute the loss for each area (25 seconds), the passive forecasts are issued only on a weekly basis. Environmental effects which are of sufficient magnitude to significantly alter the amount of propagation loss encountered can and do occur on a daily basis. This in turn has a marked effect on the tactical employment of passive airborne acoustic sensors since the range to which these sensors are effective is determined to a large extent by the amount of loss encountered.

Figure 1 is an example of a passive propagation loss forecast for a particular Pacific Ocean region. In this instance, the layer depth was 200 feet, the below layer gradient was -5°F/100 FT, and the shallow-shallow or in layer case was utilized. It will later be shown that the highest frequency (1700 HZ) is being propagated via the ducted mode, the 300 HZ case has marginal ducting (300 HZ is close to the lowest frequency which can be ducted in a 200 foot layer), and the 50 HZ frequency is propagated by modes other than ducted transmission. From this figure, it can be seen that the ducted mode of transmission is the most efficient means of transmission since less loss is encountered as range increases.

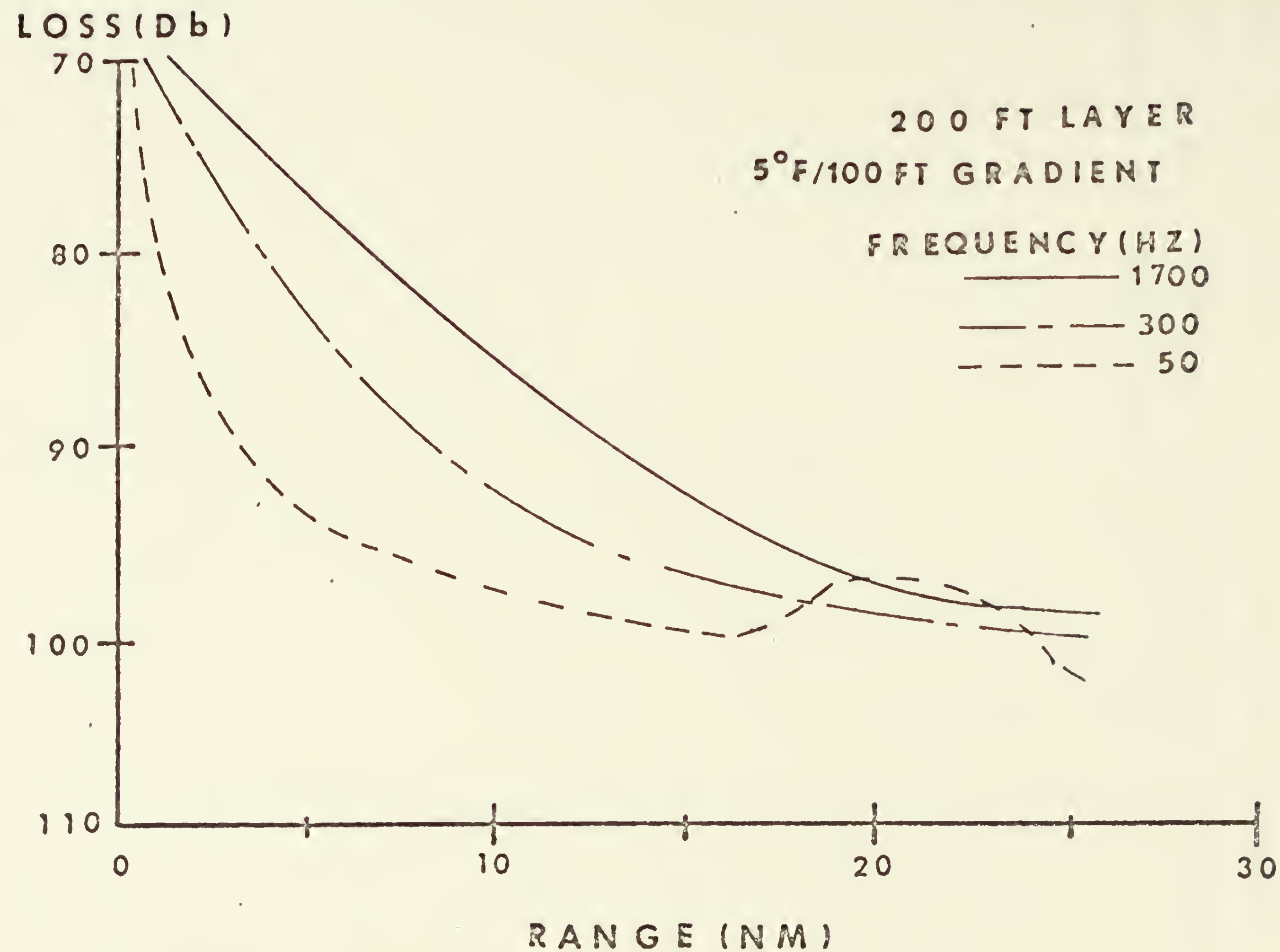


Figure 1. Propagation loss profiles for a typical Pacific Ocean location.

The method subsequently developed in this thesis will be concerned with the case where sonic energy is trapped within a surface duct. It is this case which is best suited to an analytical algorithm which can be utilized to perform the desired updating of forecasts.

II. SURFACE DUCT PROPAGATION LOSS MODEL

The loss of acoustic energy, propagation loss, within a surface duct is comprised of essentially two factors, geometrical spreading and signal attenuation. Geometrical spreading reduces the power per unit area present within a duct by distributing it over a larger area. The signal attenuation is comprised of those physical factors which cause a reduction in the intensity of the sonic energy present within the duct. These factors are leakage of the signal from the duct, absorption of energy due to chemical and viscous relaxation mechanisms, and the scattering of sonic energy from a roughened sea surface. Figure 2 illustrates the losses which occur within the surface duct.

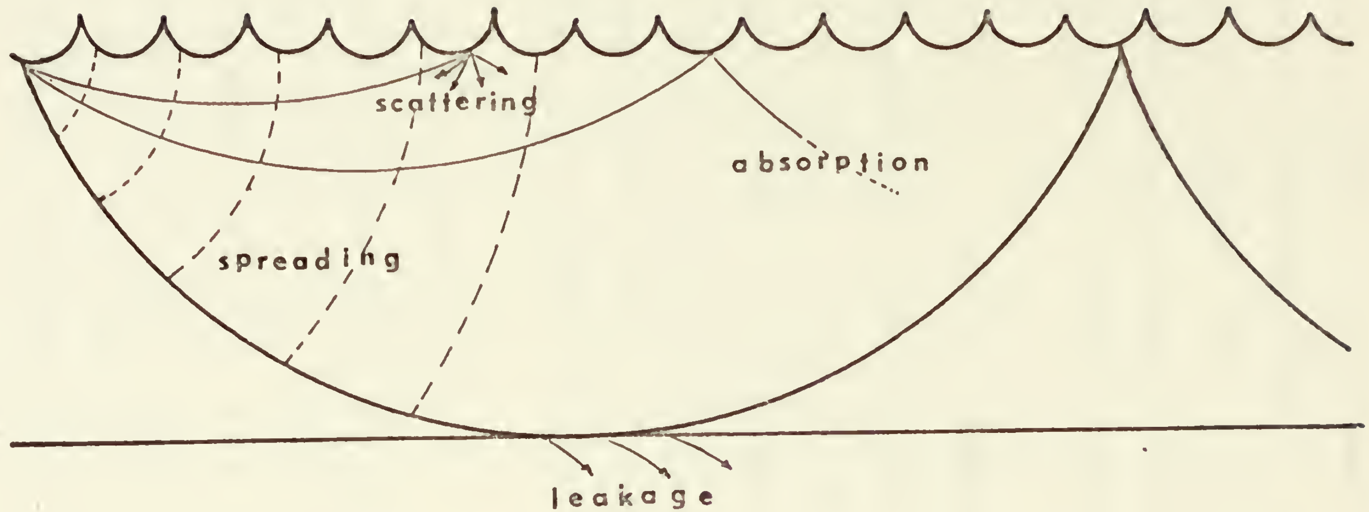
In the method employed by the Fleet Numerical Weather Central, Monterey (FNWC) to determine the amount of propagation loss encountered, analytic expressions are evaluated by application of certain governing environmental parameters. These parameters are above and below layer sound velocity gradients, mixed layer depth, and sea state. They are defined as:

H - the mixed layer depth in FT

G - the below layer sound velocity gradient in FT/SEC/FT

Ga - the above layer sound velocity gradient in FT/SEC/FT

F - the frequency in KHZ



PROPAGATION LOSS = spreading + leakage + scattering + absorption

Figure 2. Losses occurring in a surface duct.

SC - the scattering coefficient defined as 9 for sea states less than 3 and 18 for sea states greater than or equal to 3.

The velocity gradient terms, G and Ga, are considered a function of pressure and temperature only since the effects of salinity are assumed negligible. The pressure effect is given as 0.018 FT/SEC/FT. The thermal effect on the sound velocity gradient can be approximated by a linear function of temperature. For a thermal gradient, G_t, given in °F/100 FT,

$$G = 5.842 \times 10^{-2}(G_t) \text{ FT/SEC/FT.}$$

The velocity gradient below the mixed layer is then given as

$$G = 5.842 \times 10^{-2}(G_t) - 0.018 \text{ FT/SEC/FT}$$

when the absolute value of G_t (assumed to be always negative) is used. The above layer gradient, Ga, is found in a similar manner. Ignoring the effects of slight temperature gradients (fractions of a degree F/100 FT), this gradient is given as

$$Ga = 0.018 \text{ FT/SEC/FT.}$$

Following the development of Urick (1967), the spreading loss within a surface duct is given as:

$$\text{Spreading Loss (dB)} = 10 \log_{10} R \cdot R_0 \qquad (1)$$

where R is the range from the source in yards and R_0 is the transition range. The transition range is defined as the range at which the spreading transitions from spherical to cylindrical. An alternate manner in which to view this is

$$\text{Spreading Loss (dB)} = 20 \log_{10} R_0 + 10 \log_{10}(R-R_0)$$

where the parameters are as defined above. The spherical

term, 20 $\log_{10}R_0$, can be thought of as having two cylindrical spreading components, one in the horizontal and another in the vertical. Horizontal cylindrical spreading then occurs at all ranges, R, while cylindrical spreading in the vertical occurs to an effective layer depth, He, which is equivalent to the transition range, R_0. The net effect is that spherical spreading occurs until the boundaries of the duct are reached and then cylindrical spreading occurs. For simplicity in notation, the loss associated with the transition range, R_0, will be termed the effective layer loss. The transition range, R_0, is given as

$$R_0 = (H/3)/2 \sin \theta$$

where θ is the maximum angle of the limiting ray. This angle is given as

$$\theta = ((2H/3)/r)^{1/2}$$

where r is the radius of curvature of the rays trapped within the duct. For a duct with a constant above layer gradient, Ga,

$$r = C_0/Ga$$

where C_0 is the vertex sound velocity. For $r >> H$, the transition range R_0 is given by

$$R_0 = ((r \cdot H/3)/2)^{1/2}$$

when the source is at the surface of the duct. The total

spreading loss within the duct then becomes,

$$\text{Spreading Loss (dB)} = 10 \log_{10}((r \cdot H/3)/2)^{1/2} + 33 + 10 \log_{10} R$$

when R is in NM. The first term of this expression is dependent upon the layer depth H and the above layer gradient Ga. For an isothermal layer, the normal situation creating a surface duct, this term becomes wholly dependent upon the layer depth. The second term of this expression is independent of the environmental parameters and is a function of range alone. Thus the spreading loss has been separated into a range dependent term and a term which is dependent upon the environmental parameter of layer depth.

The loss due to signal attenuation is given by the duct equation

$$\text{Attenuation Loss (dB/NM)} = 14.88 \times 10^{5}(F^{-5/3}G^{-1/3}H^{-3}) + (1/8)F^{2} + SC(F/H)^{1/2} \qquad (2)$$

for frequencies below 1 KHZ. For frequencies above 1 KHZ, the term $(1/8)F^2$ is replaced by $2F^2((0.1/(1+F^2))+(40/(4100+F^2)))$. This equation contains a leakage attenuation term, an absorption term, and a sea surface scattering term.

The leakage attenuation term, $F^{-5/3}G^{-1/3}H^{-3}$, was developed from normal mode theory by Clay (1968) and accounts for losses which result from sonic energy leaving the duct due to diffractive leakage. It can be noted that the loss

encountered is inversely proportional to frequency, layer depth, and below layer sound velocity gradient. This relationship is intuitively plausible. As layer depth increases, the intensity or power per unit area decreases and a lesser amount of propagation loss results. Additionally, as the below layer gradient intensifies, the duct becomes a more efficient "wave guide" since the boundary discontinuity is sharper making it more difficult for sonic energy to leave the duct via diffractive leakage.

The absorption term, $2F^2\left(\frac{0.1}{1 + F^2} + \frac{40}{4100 + F^2}\right)$, accounts for the losses due to chemical and viscous relaxation. This expression was derived by curve fitting to empirical data by Thorpe and noted by Urick. This term represents the effects of the two relaxation mechanisms at a temperature of approximately 39°F. The expression, $(1/8)F^2$, is merely an approximation to the previous form for low frequencies and is utilized to simplify the computations.

The sea surface scattering term, $\left\{\begin{matrix}9\\18\end{matrix}\right\}(F/H)^{\frac{1}{2}}$, was developed from the results of Marsh and Schulkin from Project AMOS data and subsequently noted by Clay. The coefficient, 9, is used for sea states less than 3 while a coefficient of 18 is utilized for sea states greater than 3. This loss is directly proportional to the frequency and inversely proportional to the layer depth. As the source frequency increases, the sea surface appears relatively rougher due to the decrease in signal wave length. Subsequently, at higher frequencies,

this roughened sea surface accounts for a greater amount of loss. A lesser amount of scattering loss is encountered for a deepening layer depth due to the decreased intensity within the duct as previously mentioned for the leakage attenuation term. The constant, 14.88×10^5, serves as a unit conversion factor for loss in dB/NM.

The maximum wavelength, λmax, for a given duct is given by Urick as,

$$\lambda max = 4.7 \times 10^{-3} H^{3/2}.$$

For an average sound velocity of 5000 FT/SEC, the lowest frequency which can be ducted, F_{low}, is

$$F_{low} = 5000/(4.7 \times 10^{-3} H^{3/2})$$

$$= 1.08 \times 10^{6} H^{-3/2} \qquad (3)$$

It should be noted that this lower limit is not sharply defined and that ducting at lower frequencies may be encountered, particularly in regions of weak below layer thermal gradients. Because of the approximate nature of this cutoff, frequencies as low as $0.7\ F_{low}$ are allowed to be ducted in the actual computational procedure.

When non-ducted propagation is the case in question, the only losses which can be calculated in a relatively simple manner are spherical spreading and absorption. This is because the exact solution to this propagation mode may be dependent on multiple path transmission and phase coherence effects. The loss due to spherical spreading is

given by

$$\text{Spherical Spreading Loss (dB)} = 66 + 20 \log_{10} R,$$

where R is in NM. The loss due to absorption can be determined through use of the absorption formula previously mentioned.

The loss which is encountered when sonic energy must pass through the mixed layer is termed the cross-layer loss. This case occurs when the source is within the duct and the receiver is below the duct or vice-versa. The Fleet Numerical Weather Central, Monterey uses a fixed loss parameter of 10 Db for this loss (Pers. comm., J. Clark, June 1972). In the absence of more complete empirical data upon which to further quantify this loss, the 10 Db approximation is also utilized in this paper.

III. COMPUTATIONAL PROCEDURE

The computational procedure utilized consisted of essentially two FORTRAN programs. The first program was utilized to determine the amount of loss due to the duct equation (equation 2) while the second was used to find the value of losses due to spreading (equation 1). These programs are listed in Appendix B.

Program 1 iterates the duct equation over the specified domain limits for the environmental variables involved. The layer depth was iterated from 50 to 750 FT in 25 FT increments. The below layer thermal gradient was allowed to change from -2°F/100 FT to -20°F/100 FT in 2°F/100 FT steps. Frequency was allowed to change in 100 HZ steps from 100 to 2400 HZ and the sea state changed from low to high. The iteration took place in such a manner as to generate a set of tables for each frequency and sea state combination which yielded the value of the duct loss parameter as a function of layer depth and below layer thermal gradient. Since the low frequency cut-off equation is not sharply defined, frequencies as low as 0.7 F_{low} were allowed to be ducted. For frequencies lower than 0.7 F_{low}, the loss value was set equal to a number larger than the field width allocated for printing the values. Thus the symbol **** was printed indicating a field-width over-ride machine function. The printing of tables in this manner allowed for some variance in the low frequency cut-off while at the same time

eliminating the chance for improper interpretation of duct loss values, that is, the misinterpretation of a duct loss value when ducting is not likely is minimized. Several subroutines were utilized within the program to present the results in graphical form. Subroutine DRAW transforms digital data into a form which can be utilized by an offline plotter. Subroutine CONTUR performs a scalar field analysis with a 0.2 dB/NM contour interval. After this analysis, the data is transformed into a form acceptable for an offline plotter. To facilitate the interpretation of these plots, a variable contour interval was utilized in regions of rapid loss gradient change, e.g., in regions where the conditions for ducting were marginal.

Program 2 was utilized to compute the losses due to spreading and for the development of peripheral tables and graphs. The development of these tables and graphs is accomplished through the use of the equations presented in the previous section. Subroutine PLOTP was used to plot the online graphs. The output of this program consisted of the following:

Table A-1: Low frequency cut-off and effective layer loss as a function of the layer depth.

Table A-2: The ducted (cylindrical) spreading loss.

Table A-3: The non-ducted (spherical) spreading loss.

IV. FACTORS AFFECTING THE VARIABILITY OF DUCTED PROPAGATION LOSS

The variations in ducted propagation loss can be best treated by first examining the term which is not range dependent – in this case, the spreading loss associated with the transition range, R_0, or the effective layer loss. Recall that this loss is given by $10 \log_{10}((r \cdot H/3)/2)^{1/2})$ where the radius of curvature of the entrapped rays, r, is given by C_0/Ga and H is the mixed layer depth. When an isothermal layer is assumed, the dominant term in this expression becomes the layer depth, H. This parameter can vary over a range of values from 0 FT (or no layer depth) to perhaps 1000 FT where half-channel conditions are likely to persist. At mid-latitudes, the range of this parameter is restricted to values within the range from 0 to 500 feet under normal circumstances. The range of values examined in this study varied from 50 to 750 feet. This range of values encompasses the duct dimensions in which frequencies from approximately 3 KHZ to 50 HZ can be ducted in accordance with the frequency cut-off equation previously noted. The results of this analysis are delineated in Table A-1, Appendix A, and are graphically illustrated in Figure 3. The range of propagation loss values which were encountered varied logarithmically from 29.4 dB at a layer depth of 50 FT to 35.3 dB when the layer reached 750 FT. At the shallower layer depths, this parameter is more sensitive to change than at deeper layer

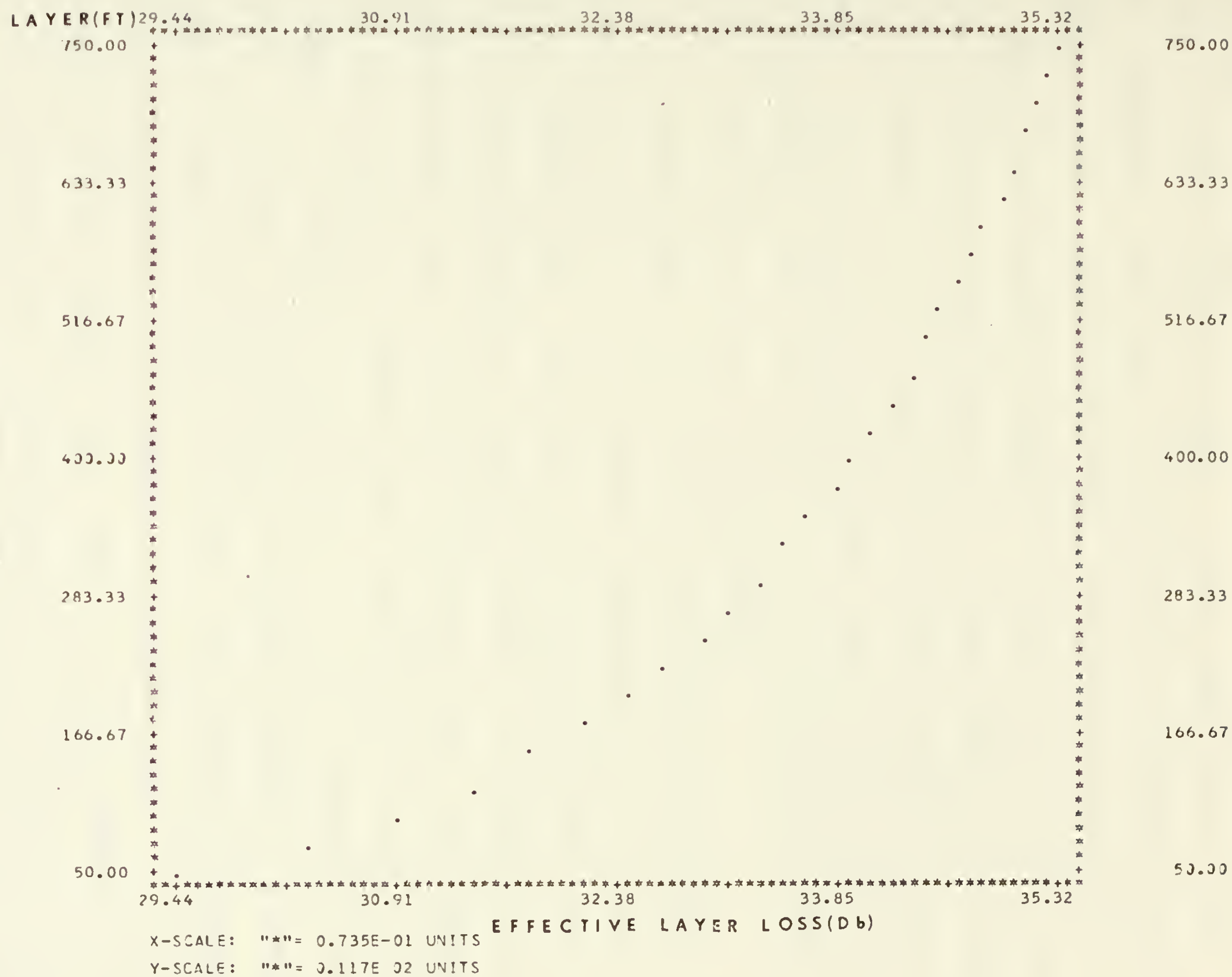


Figure 3. Effective layer loss as a function of layer depth.

depths. For example, a change of 100 feet, from a 50 FT to a 150 FT layer depth, results in a 2.4 dB change in the loss, from 29.4 dB to 31.8 dB. On the other hand, a 100 foot change in layer depth from 650 FT to 750 FT results in only a 0.3 dB change in the loss, from 35.0 dB to 35.3 dB.

When the source is located at the mid-point of the vertical dimension of the duct, a 1.5 dB decrease in the amount of loss results at all layer depths due to reduced transition range. Since source location within the duct is difficult to ascertain, this effect will be neglected and all sources will be assumed to exist at the surface.

A second effect which alters the amount of spreading loss encountered in the effective layer term is the above layer gradient, Ga. When the above layer gradient is not isothermal and assumes a positive value, the amount of loss decreases due to a decreased transition range. The magnitude of this change was found to be 3 dB/1°F/100 FT temperature change. It should be noted that by strict classical definition, no "layer" exists when the thermal gradient is positive. None the less, a surface duct does exist and has dimensions from the surface to the depth at which the positive gradient merges with the thermocline. FNWC currently normalizes all positive above layer thermal gradients to isothermal conditions since this gradient condition is most likely transient in nature and is not likely to persist. This positive gradient effect can therefore be neglected.

To examine the changes in propagation loss which result due to changing environmental parameters or changing source frequencies, the duct equation must be analyzed. Perhaps the best manner in which to examine this variability and observe the resultant sensitivity is to hold one or more of the variables constant while allowing the others to be perturbed over the range of values likely to be encountered. Recall that the duct equation is given by

$$\begin{aligned} \text{Attenuation Loss(dB/NM)} = {} & 14.88 \times 10^5 (F^{-5/3} G^{-1/3} H^{-3}) \\ & + 2F^2(0.1/(1+F^2) + 1/(4100+F^2)) \\ & + \left\{ {9 \atop 18} \right\} (F/H)^{1/2}. \end{aligned}$$

This equation has five pertinent dimensions or parameters: frequency, layer depth, below layer gradient, sea state, and the resulting propagation loss. Since a five dimensional representation would be difficult to interpret and perhaps impossible to graphically represent, the problem can be best approached by examining several three dimensional representations which will serve to illustrate the sensitivity in the variables involved.

The first of these three dimensional representations to be considered is the loss surface formed when layer depth and below layer gradient are allowed to vary when frequency and sea state are held constant. This is depicted in Figures 4 through 6. From these Figures it can be noted, that, except at relatively shallow layer depths and low frequencies,

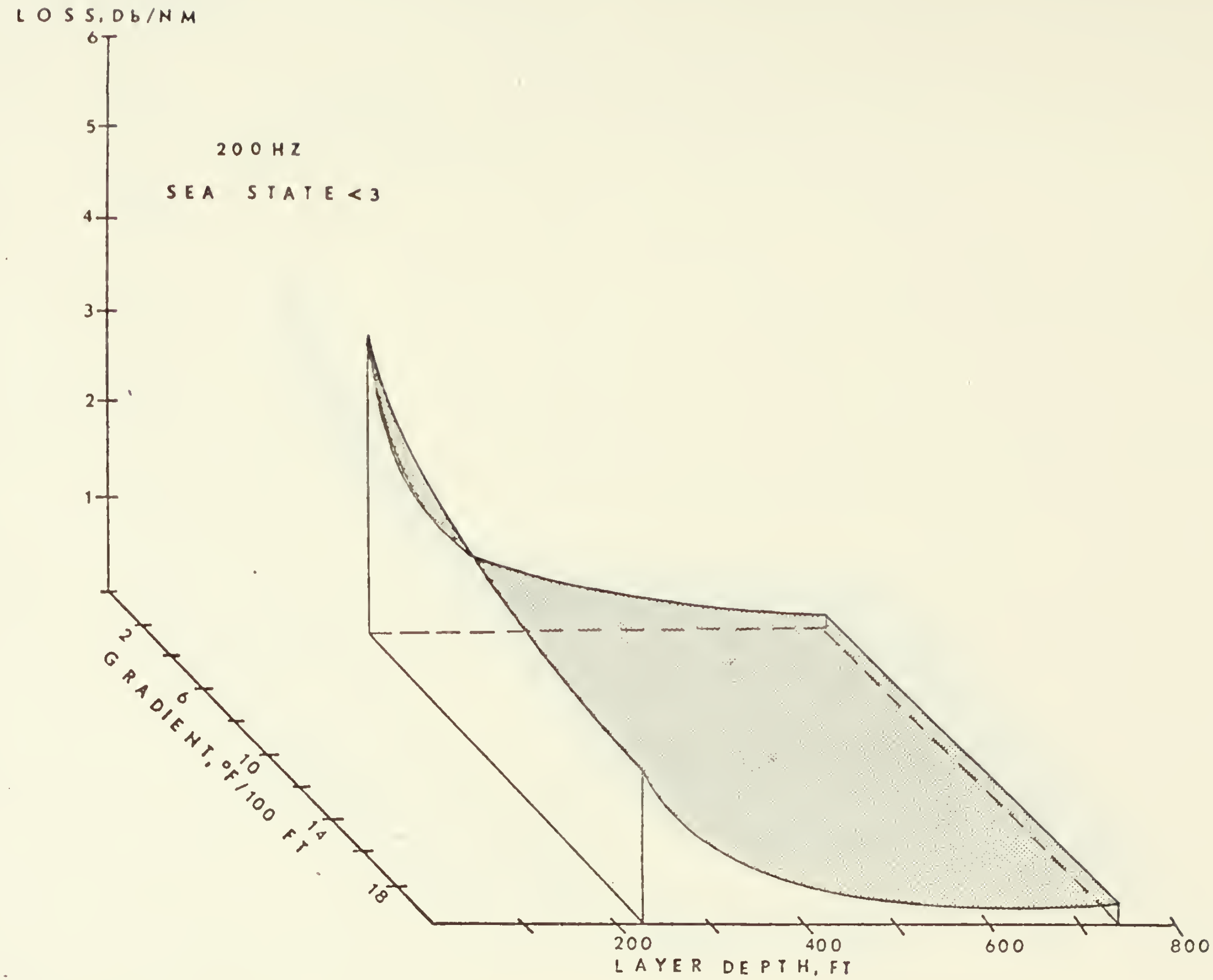


Figure 4. Loss contour surface as a function of below layer thermal gradient and layer depth for 200 Hz.

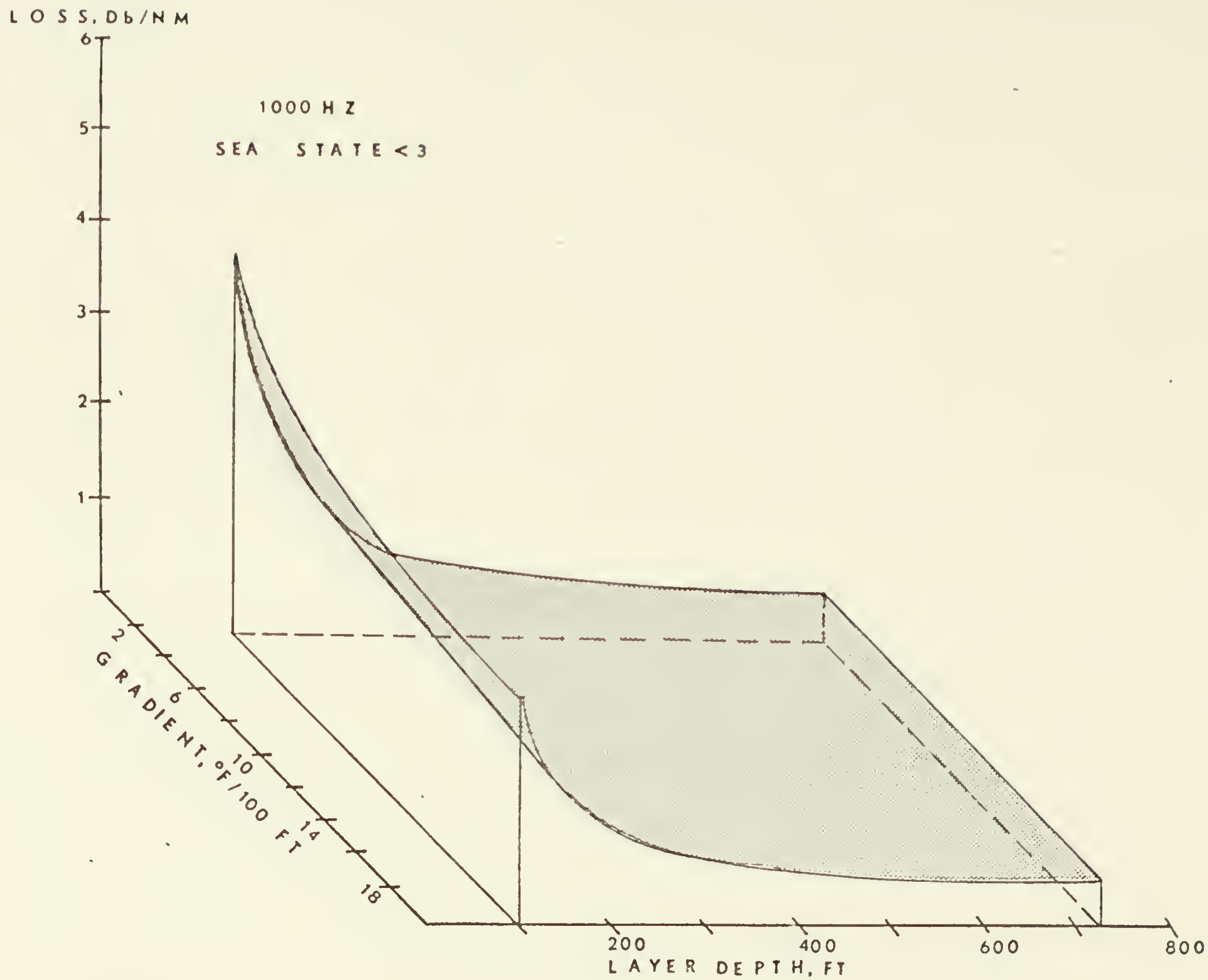


Figure 5. Loss contour surface as a function of below layer thermal gradient and layer depth for 1000 HZ.

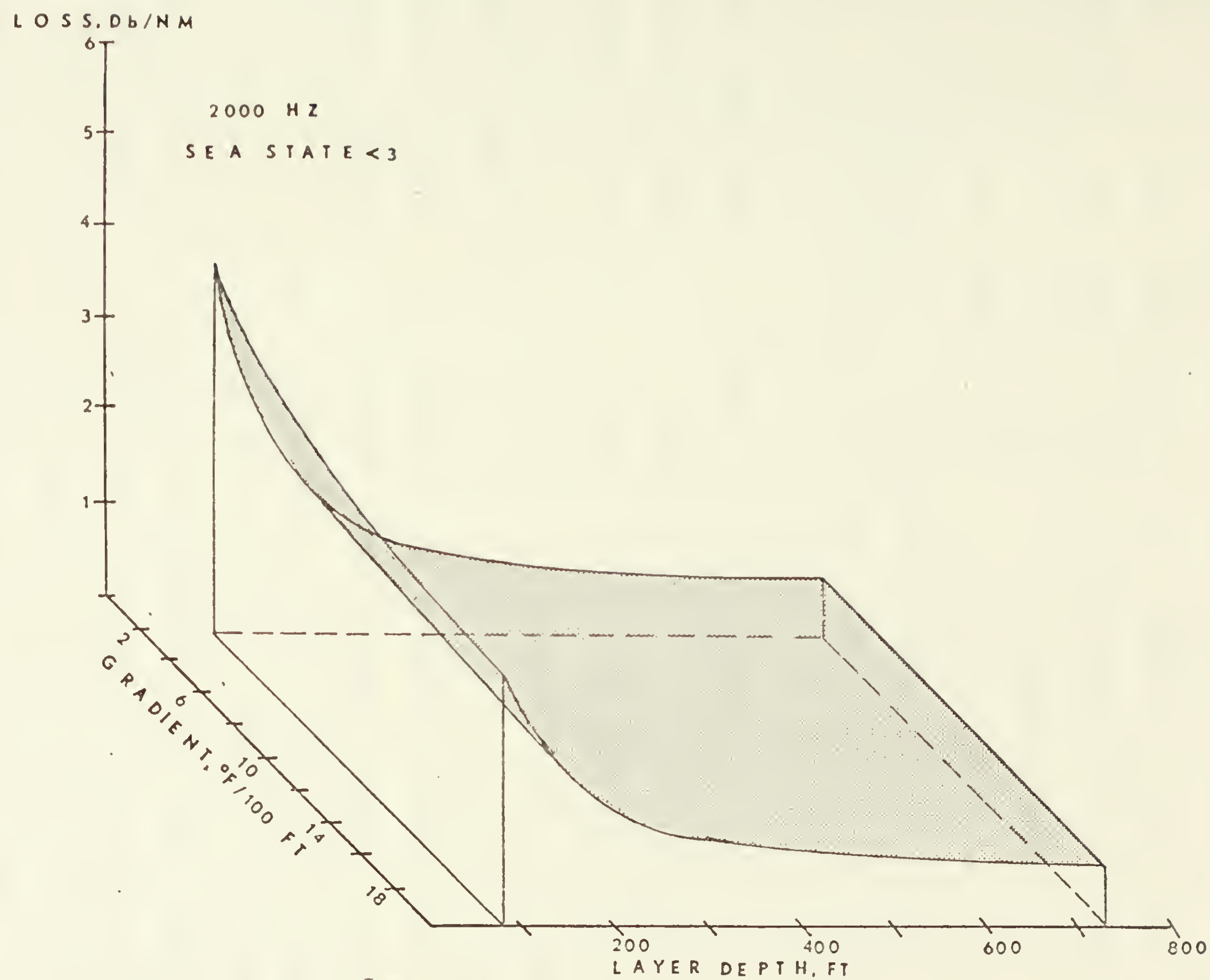


Figure 6. Loss contour surface as a function of below layer thermal gradient and layer depth for 2000 HZ.

layer depth has the greatest effect. This can be further illustrated by examining Figures 7 through 10. These plots show iso-loss contours for a fixed frequency and sea state over the ranges examined for layer depth and below layer gradient. Note that at deeper layer depths and at higher frequencies, the contour lines tend to become parallel to the below layer gradient axis signifying little dependence upon this parameter. At relatively shallow layer depths and a lower frequencies, the below layer gradient becomes significant. For example, in Figure 7 for 200 Hz, at a 250 foot layer depth, a change in gradient from 2°F/100 FT to 4°F/100 FT results in a change in loss of approximately 1 dB/NM. In contrast, Figure 10 for 2000 Hz shows that for any given layer depth, there is negligible (less than 0.1 dB/NM) change in loss over the entire range of below layer gradient values. Note that as the frequency increases, the contour spacing at relatively shallow layer depths decreases, indicating a stronger dependence on the layer depth parameter.

Since the layer depth and frequency appear to have the most effect on the resultant propagation loss over a wide range of domain, a similar loss surface can be constructed by holding the below layer gradient and sea state constant while allowing the frequency and layer depth to vary. From Figures 11 and 12, it can be seen that the regions which have the greatest change are those which lie in the vicinity of marginal ducting conditions. The term marginal ducting conditions is interpreted to mean conditions which lie in

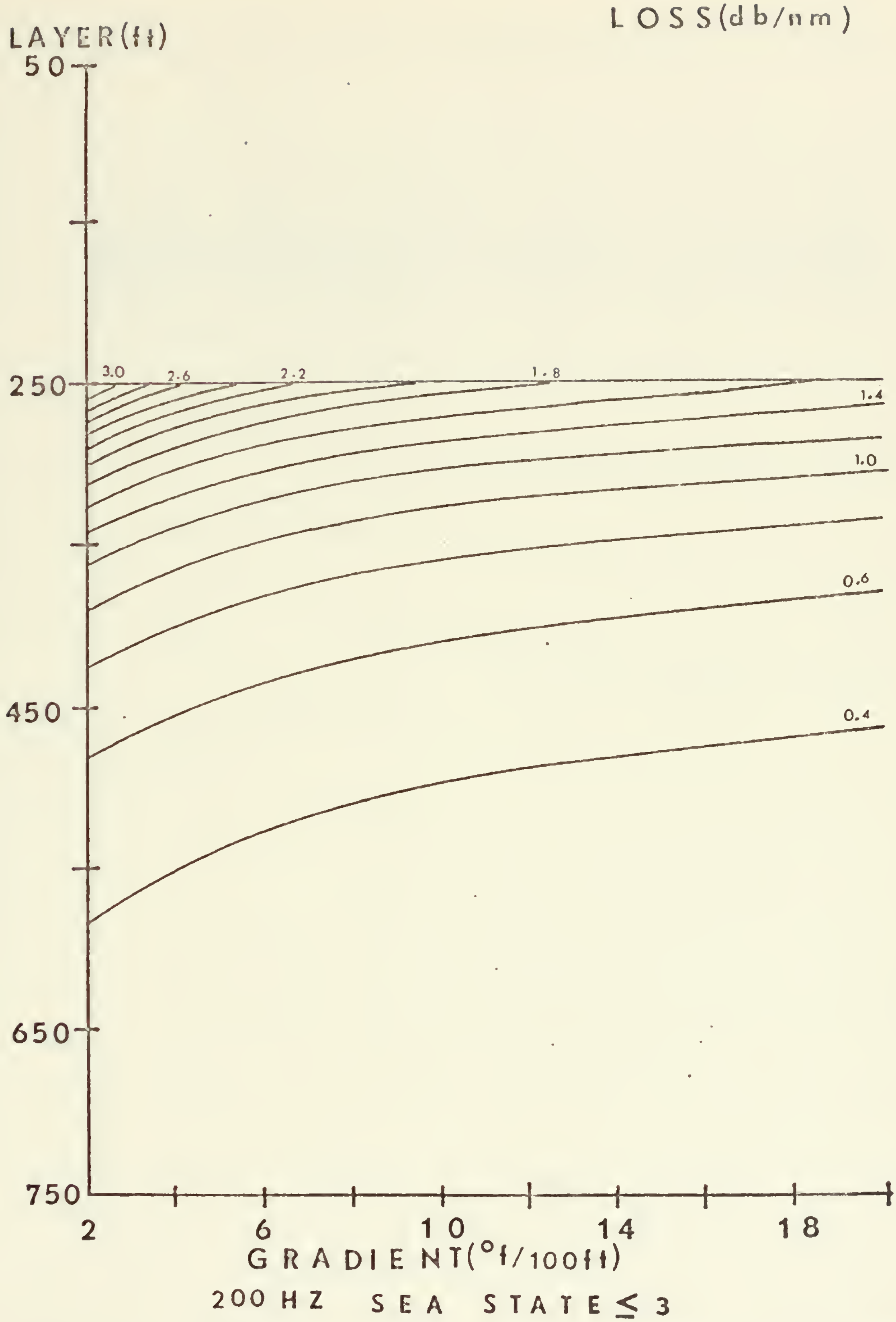


Figure 7. Iso-loss contours for 200 HZ and low sea state.

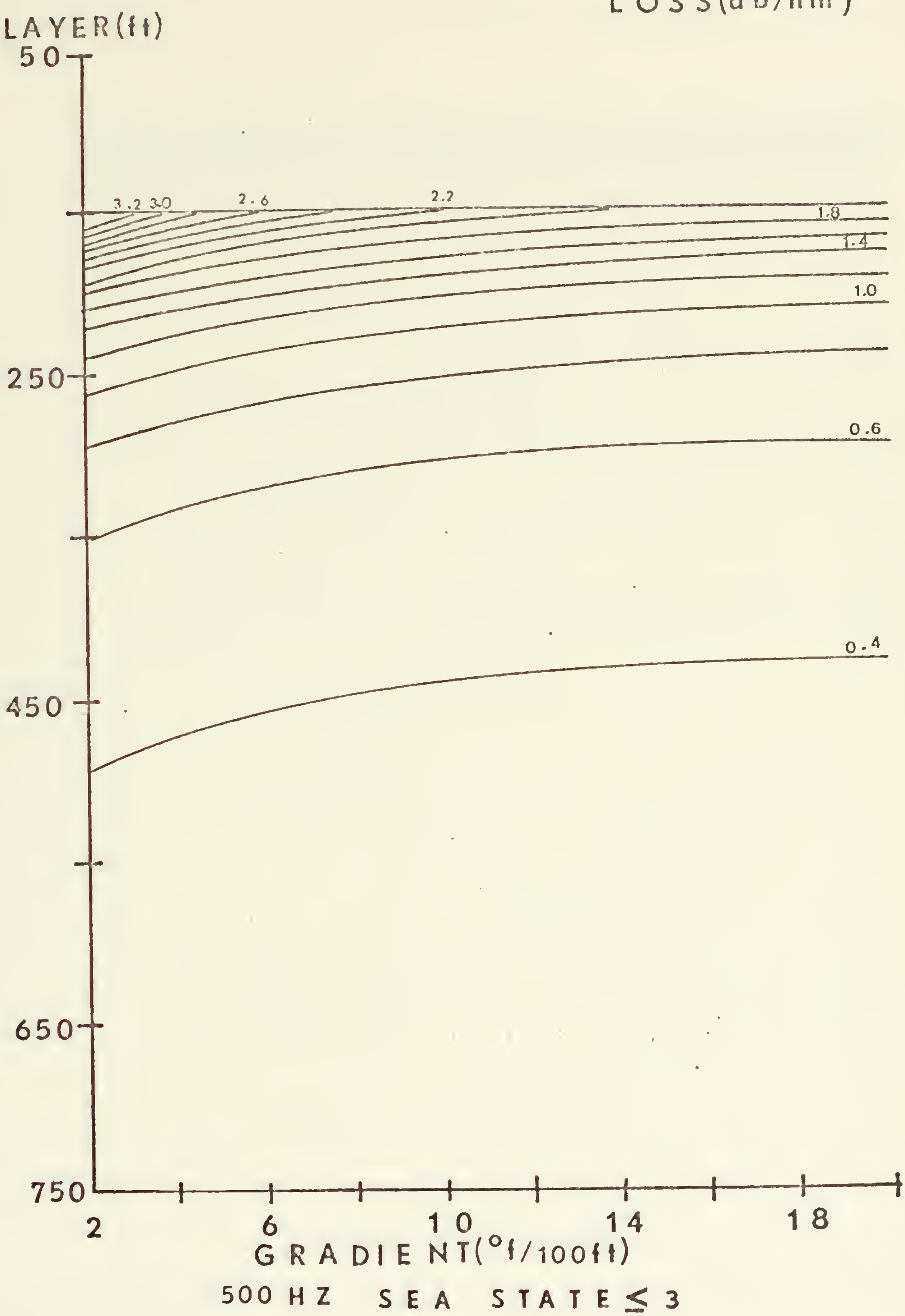


Figure 8. Iso-loss contours for 500 HZ and low sea state.

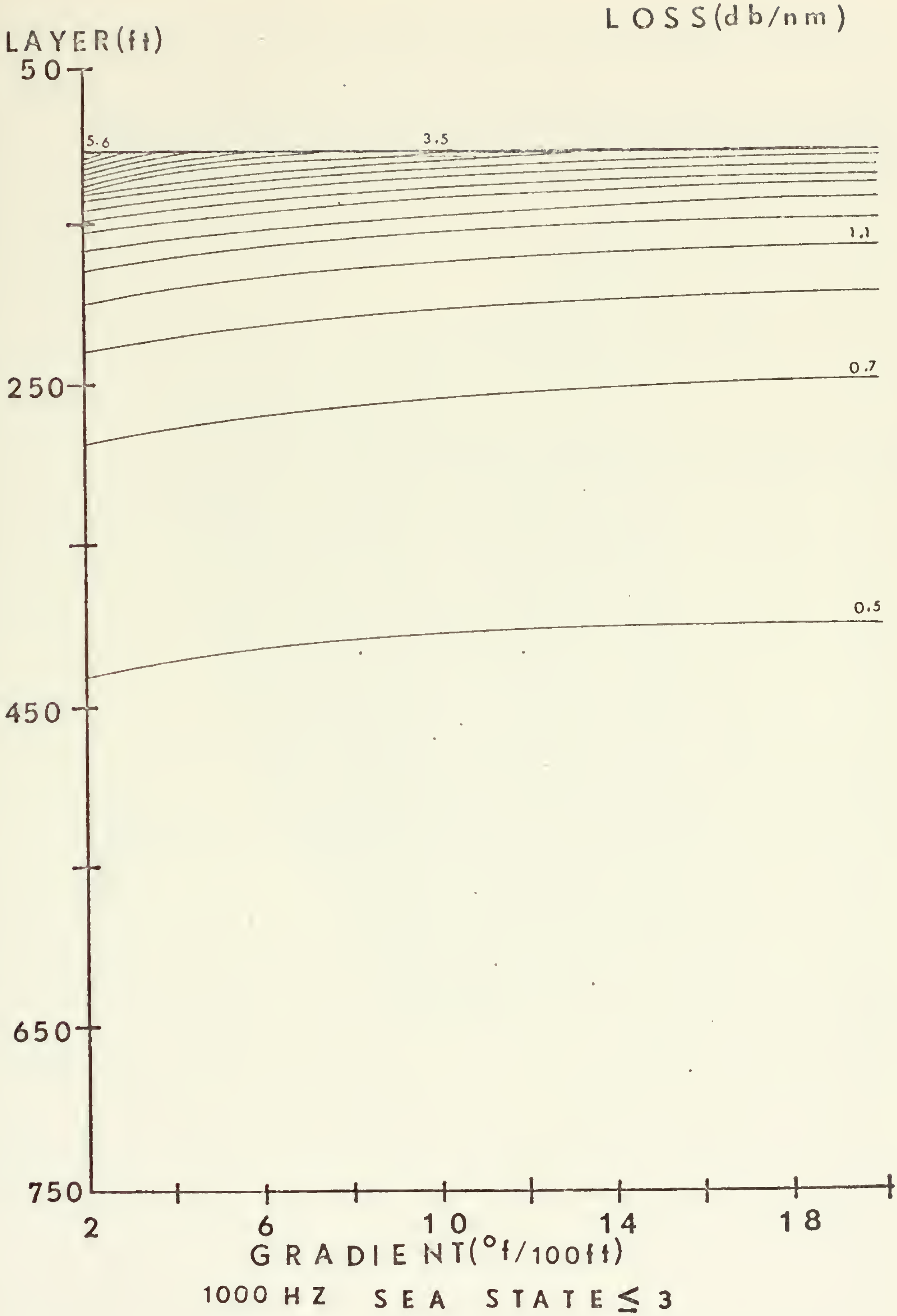


Figure 9. Iso-loss contours for 1000 HZ and low sea state.

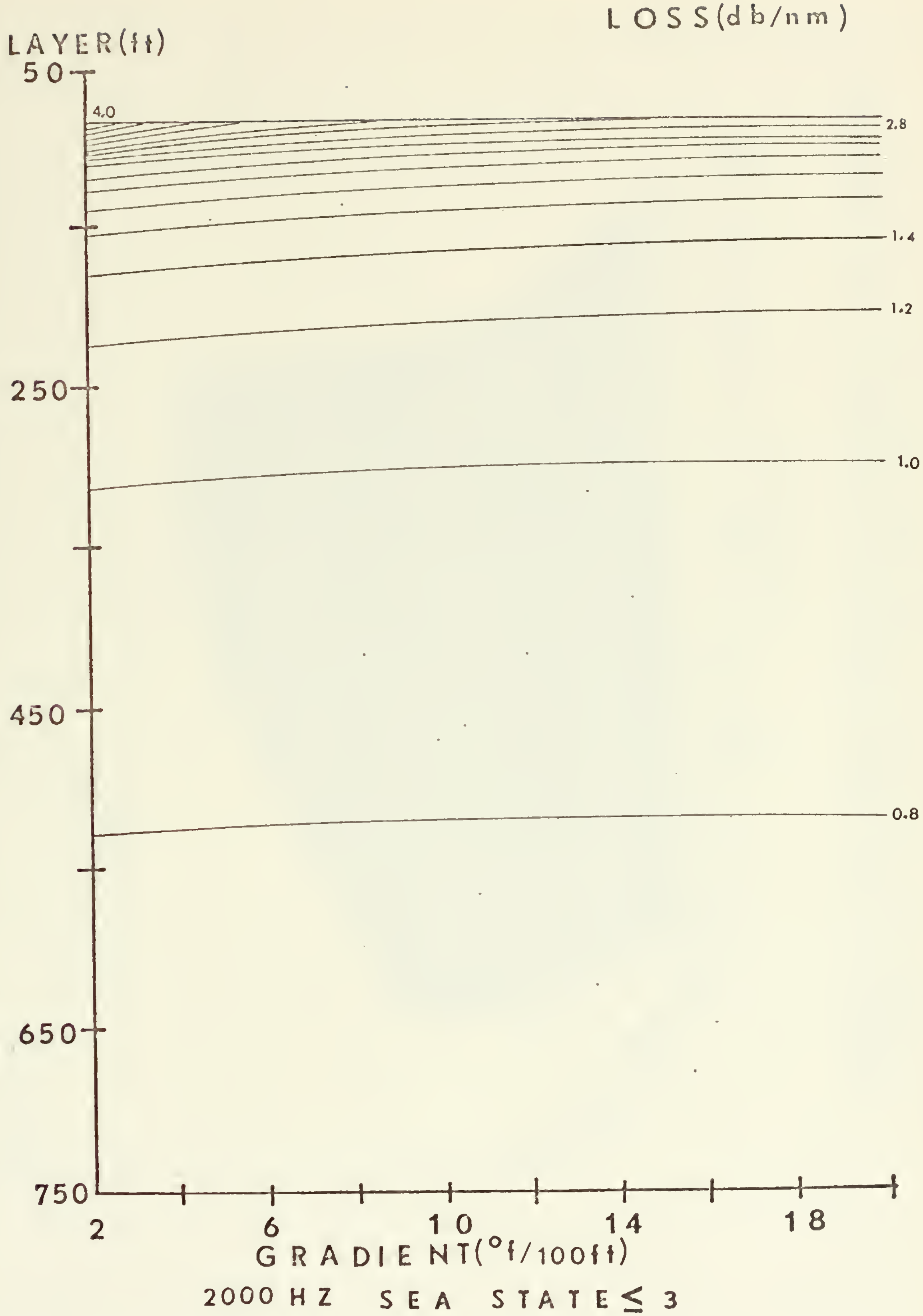


Figure 10. Iso-loss contours for 2000 HZ and low sea state.

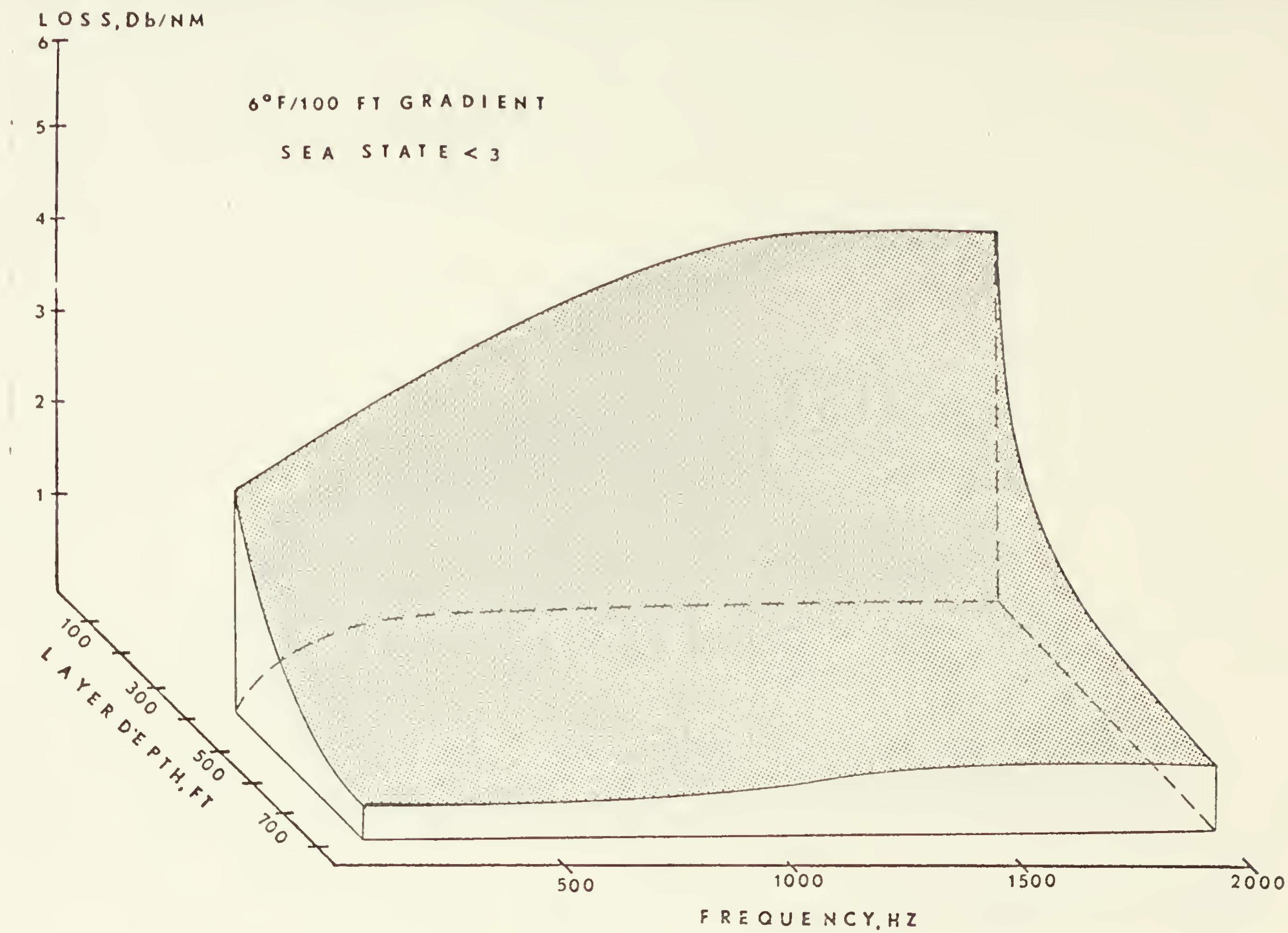


Figure 11. Loss contour surface as a function of layer depth and frequency for a -6°F/100 FT below layer gradient.

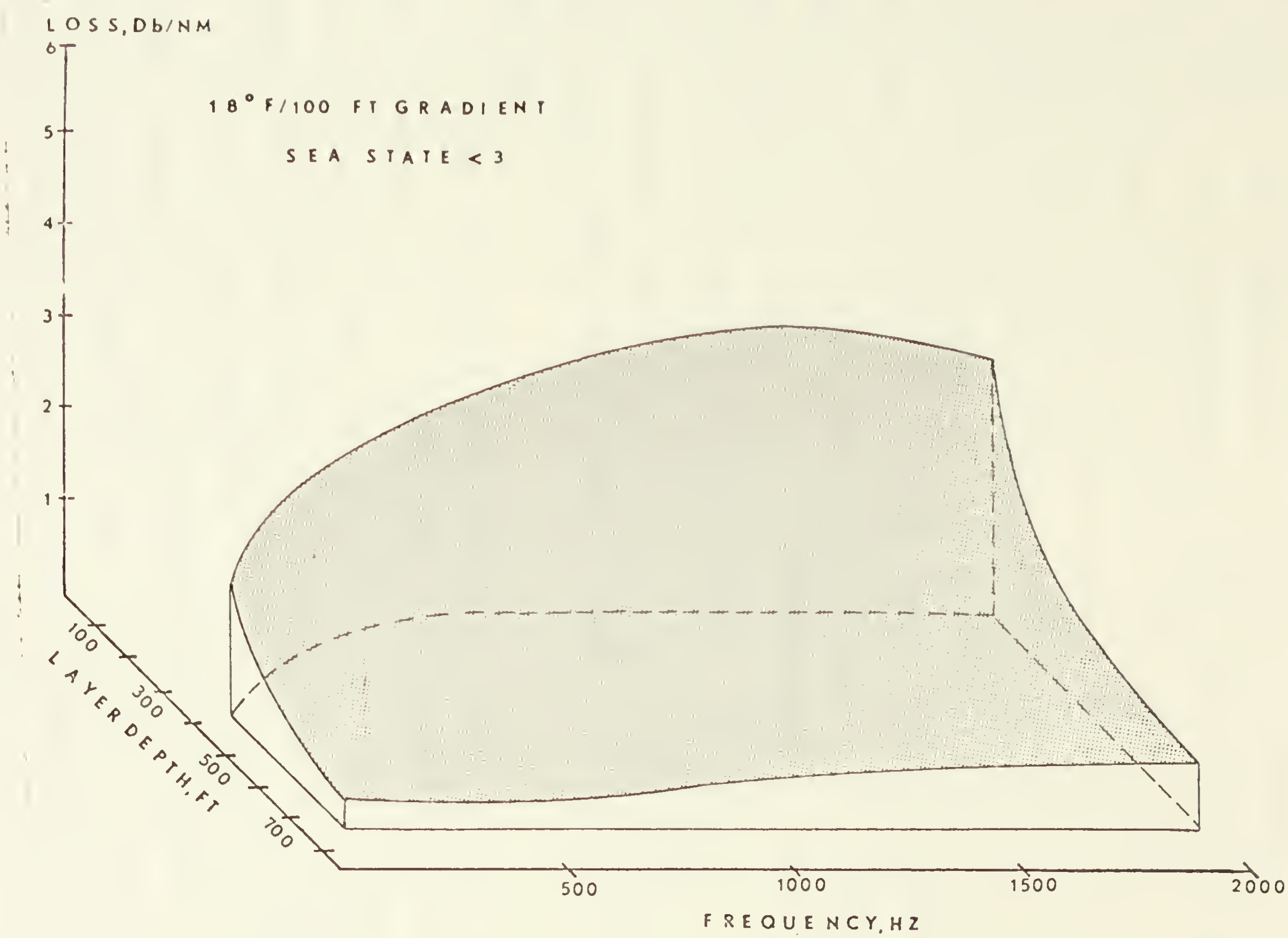


Figure 12. Loss contour surface as a function of frequency and layer depth for a -18°F/100 FT below layer gradient.

the vicinity of the limiting bounds for ducting to exist. These bounds are imposed by either low frequency or relatively shallow layer depths. Once away from these regions, the loss becomes more insensitive to changes in frequency and layer depth. This is evidenced by the loss surface tending to become parallel to the frequency-layer depth plane. To amplify this fact, it can be seen from Figures 13 and 14, that outside the area enclosed by the dashed boxes, the change in loss becomes more abrupt as either layer depth or frequency vary. Note also that there exists a finite amount of change in loss at all regions of the domain. For example, within the dashed boxes, only a 1 dB/NM change is experienced within the layer depth-frequency ranges. In contrast, outside the enclosed regions, as much as a 5 dB/NM change may result under conditions of drastic change in layer depth or frequency.

Sea state also has a marked effect on the amount of loss which is encountered. Recall that this parameter is defined as a step function from low (less than state 3) to high (greater than state 3) seas and is a function of frequency and layer depth given by $\left\{{9 \atop 18}\right\}(F/H)^{1/2}$. To examine the effect of this parameter, it is possible to note the increase in loss which results when this "step function" is applied to previously analyzed contour surfaces. From Figures 15 and 16, it can be seen that the net result of the change from low to high sea state is to elevate the loss surface by some amount everywhere in the domain considered. For the case where

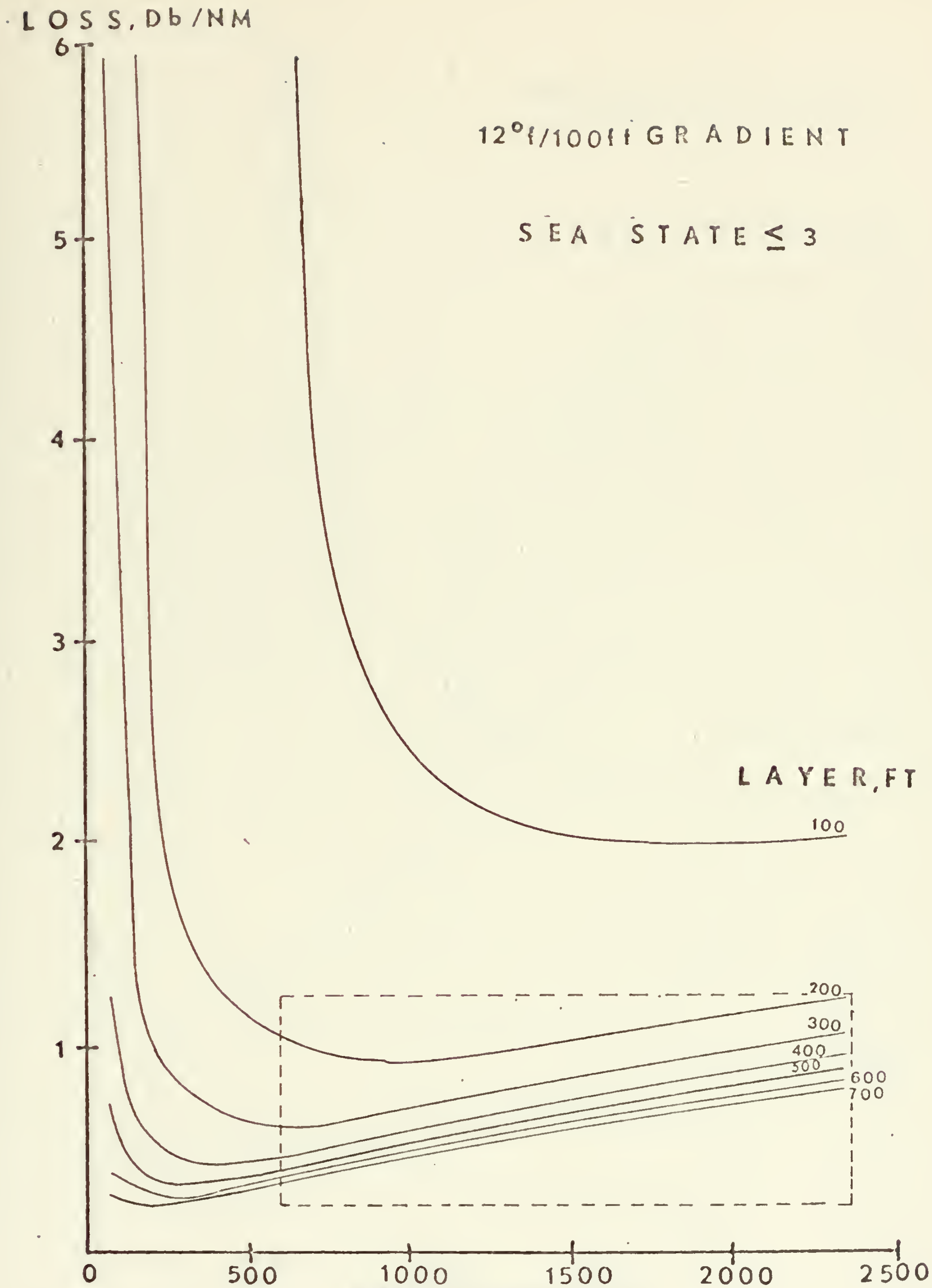


Figure 13. Propagation loss as a function of frequency for various layer depths. Below layer gradient is -12°F/100 FT.

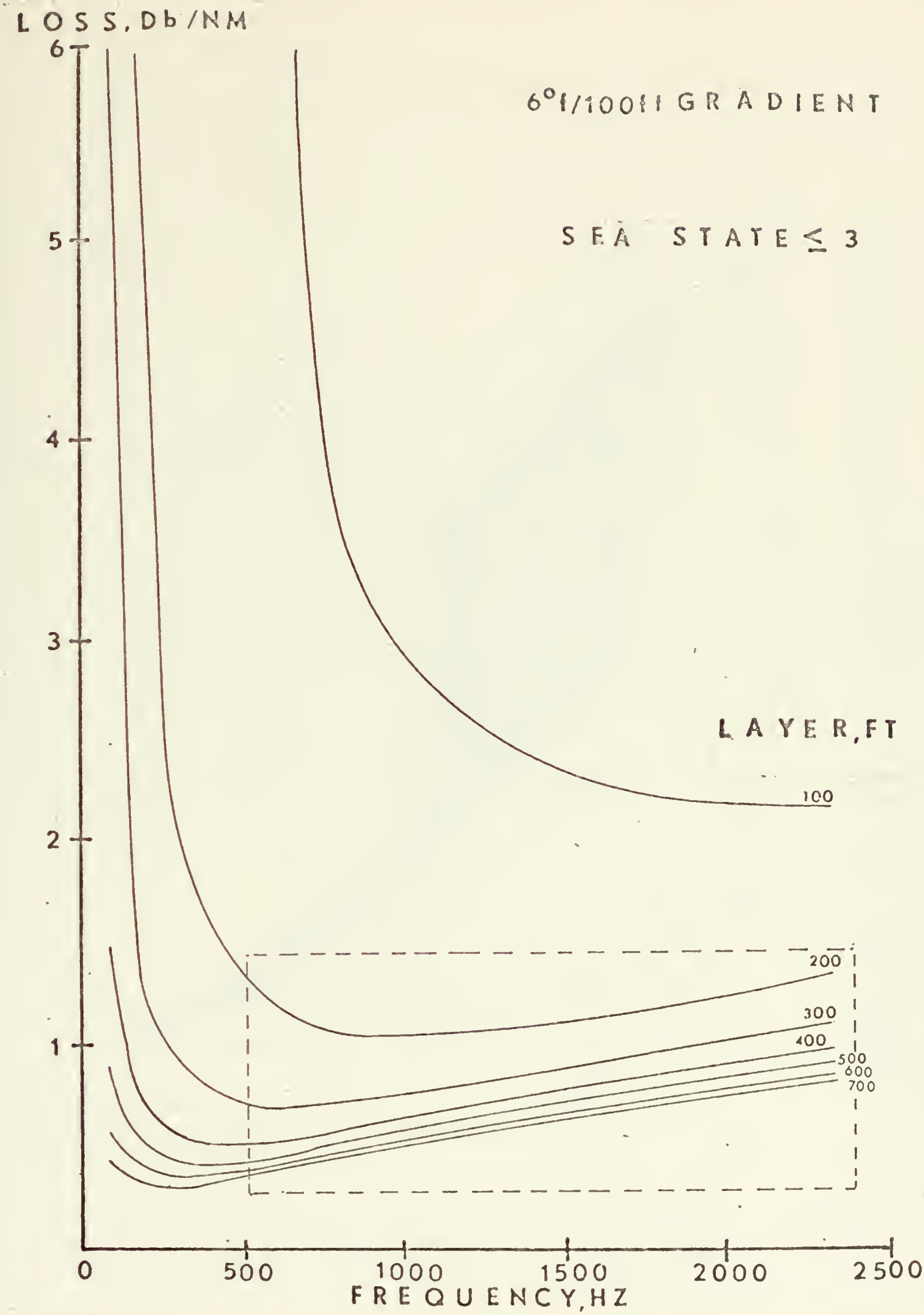


Figure 14. Propagation loss as a function of frequency for various layer depths. Below layer gradient is -6°F/100 FT.

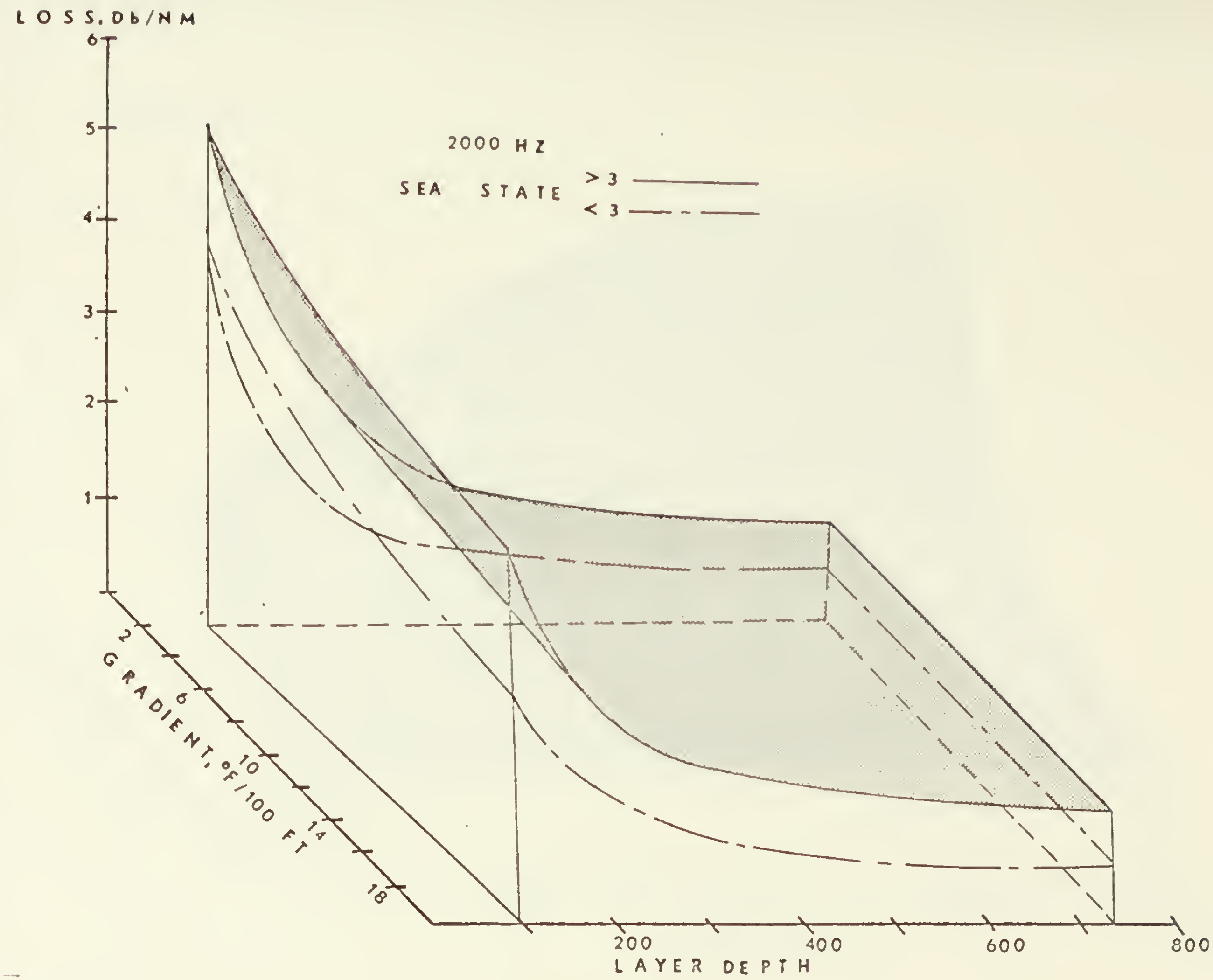


Figure 15. Loss contour surface as a function of below layer thermal gradient and layer depth for high and low sea states. Frequency is 2000 HZ.

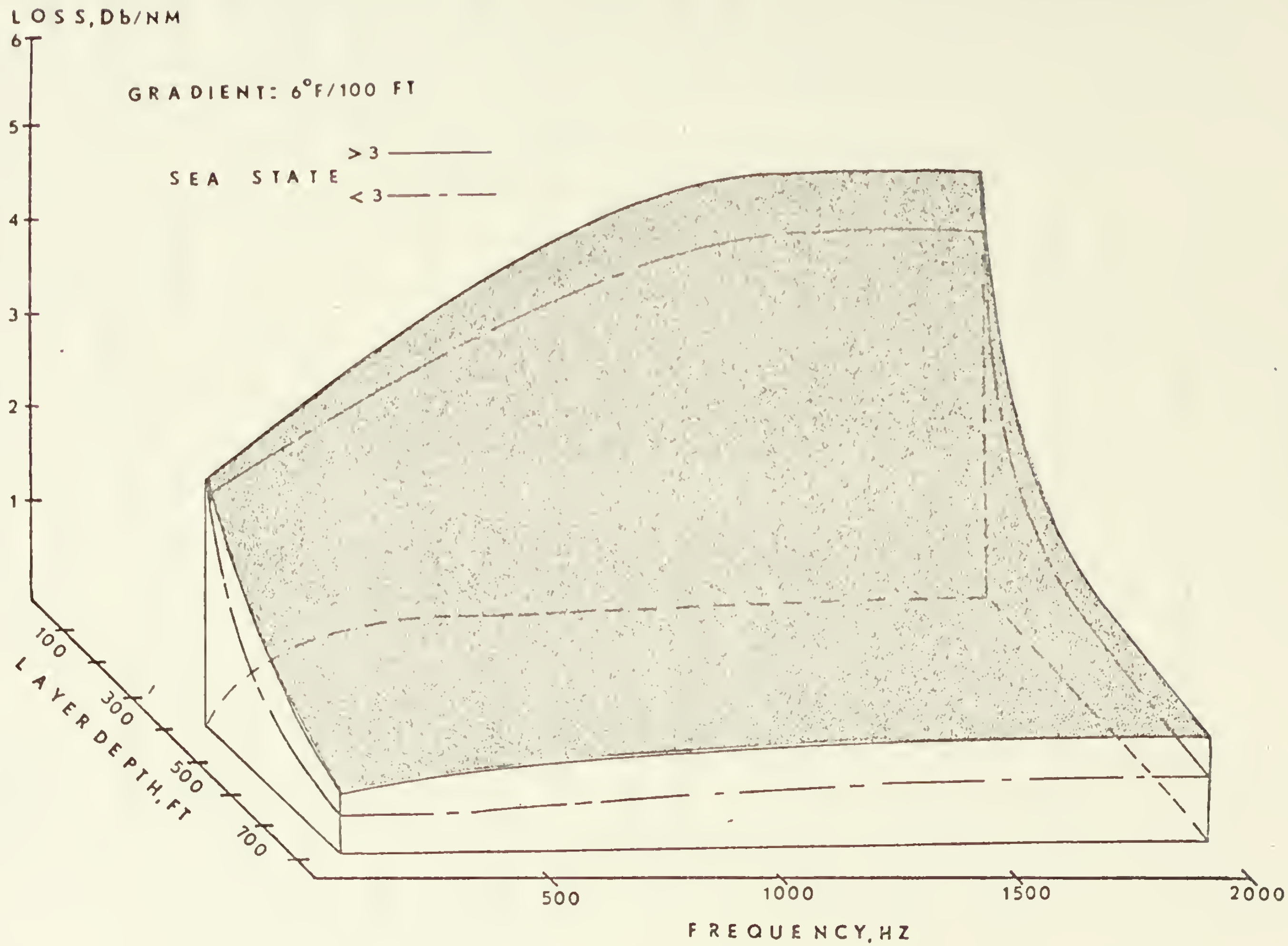


Figure 16. Loss contour surface as a function of frequency and layer depth for high and low sea states.

frequency is held constant (depicted in Figure 15), the loss surface is elevated by a constant amount of 1 dB/NM over the entire domain. When frequency is allowed to vary, the amount of elevation which results varies from 0.2 dB/NM at 100 Hz to 1 dB/NM at 2 KHz. This is illustrated in Figure 16. As the frequency increases, there is an increase in the loss gradient with respect to layer depth. This gradient increase can be seen in the divergence or widening of the spacing between the individual layer depth lines in Figure 17. When the sea state is increased (shown by the dashed lines), this divergence increases due to a stronger dependence on frequency. Thus, it can be noted that frequency has a greater effect than layer depth on the amount of propagation loss which is encountered when going from low to high sea state.

In summary, it can be stated that frequency and layer depth have the greatest effect on the amount of loss which is encountered over a relatively wide range of the domains of interest. At low frequencies and relatively shallow layer depths, the below layer thermal gradient has an appreciable effect. This is particularly notable where conditions for ducting are marginal. An increase in sea state results in an increase in the amount of loss encountered over all regions of the domain with frequency being the major factor in determining the amount of increase. Finally, the non-range dependent term associated with the effective layer depth is most sensitive at shallow layer depths.

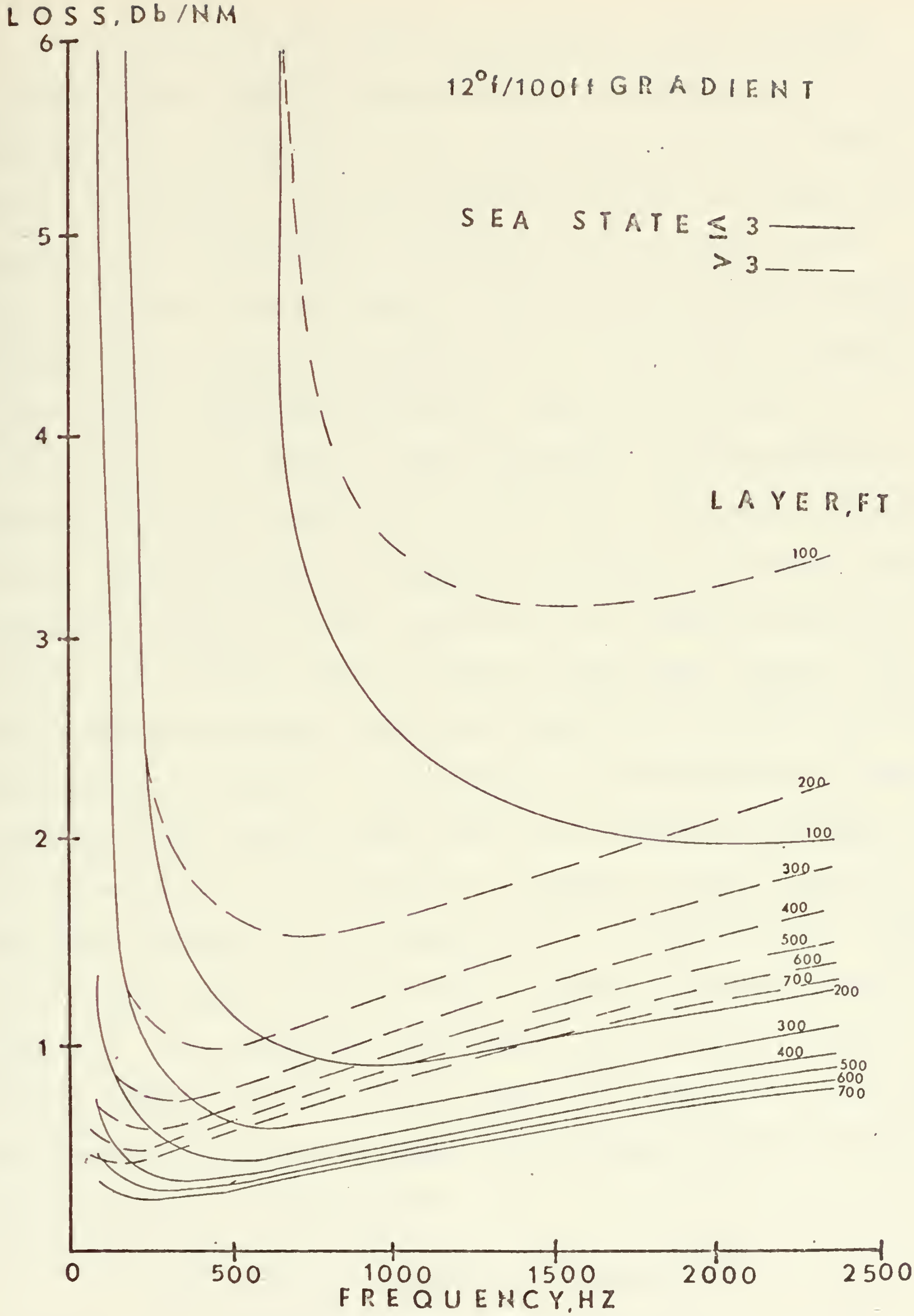


Figure 17. Propagation loss for high and low sea states as a function of frequency. Gradient is -12°F/100 FT.

To further quantify the loss gradient, it is possible to examine the rate of change in any of the governing parameters at some point within the domain while the others are held constant. A point within the domain is located or specified by delineating a frequency, layer depth, below layer gradient, and sea state. Now that this point has been uniquely specified, the gradients with respect to frequency, layer depth, below layer gradient, and sea state can be independently specified. These gradients can be found by taking the partial derivative of the loss term with respect to the variable desired, applying the amount of change desired and then evaluating this expression for a finite numerical value. An alternate method which is much less complex and yet suffices in terms of accuracy desired is a central difference numerical method. The gradient is determined by taking the difference between loss values one increment previous to the location and one increment in advance of that location and then dividing this difference by 2. The "average" change over this range is then assumed to exist at the location in question. For example, if the point 500 HZ, 300 FT layer depth, 4°F/100 FT, and low sea state were specified, the loss gradient with respect to layer depth change could be found by evaluating the expression

$$\text{Loss gradient (dB/NM/25 FT change)} = (\text{Loss}_{500,275,4,\text{low}} - \text{Loss}_{500,325,4,\text{low}})/2,$$

where the loss subscripts represent frequency, layer depth, below layer gradient, and sea state respectively.

Table I was compiled using this technique to evaluate the gradient at several points in the domain. A central difference was utilized for all cases except the frequency gradient in the 100 HZ examples and the sea state changes. A forward difference was utilized in the frequency gradient at 100 HZ. The change in the amount of propagation loss encountered due to a sea state change was noted by taking the difference in loss values occurring at high and low sea state conditions. From this table, it can be seen that the same general relationships discussed previously in terms of the three dimensional loss surfaces still hold. This table has the advantage of permitting a quantitative examination of the sensitivity of each loss parameter. For example, it was previously noted that the below layer gradient had a significant effect upon the total amount of loss encountered at relatively shallow layer depths and at low frequencies, particularly where conditions for ducting were found to be marginal. At 100 HZ, the layer depth required in strict accordance with the cut-off frequency formula is approximately 485 feet. Thus when the layer depth is specified as 500 feet, conditions for ducting should be considered marginal. From Table I, it can be seen that under these conditions, the change in loss due to a 25 FT change in layer depth is approximately equivalent to the change in loss due to a change in the below layer gradient of 2°F/100 FT. For example, if the layer depth deepened by 25 FT and the below layer gradient became less intense by 2°F/100 FT, the resultant

Locating Parameters			Loss Gradient at Location (dB/NM) per given increment			
F(HZ)	H(FT)	G(°F/100 FT)	ΔL/ΔF(100 HZ)	ΔL/ΔH(25 FT)	ΔL/ΔG(2°F/100 FT)	ΔL/ΔSS(change)
100	500	4	0.5	0.15	0.2	0.2
100	700	4	0.1	0.05	0.05	0.1
100	500	12	0.4	0.1	0.05	0.2
100	700	12	0.1	0.05	0.05	0.1
500	200	4	0.3	0.45	0.25	0.4
500	300	4	0.1	0.1	0.05	0.4
500	600	4	0.05	0.0	0.0	0.3
500	200	12	0.2	0.3	0.05	0.4
500	300	12	0.0	0.1	0.0	0.4
500	600	12	0.0	0.0	0.0	0.3
1000	150	4	0.1	0.45	0.15	0.7
1000	300	4	0.1	0.05	0.0	0.4
1000	600	4	0.05	0.0	0.0	0.4
2000	100	12	0.0	0.7	0.05	1.3
2000	200	12	0.0	0.05	0.0	0.9
2000	300	12	0.0	0.0	0.0	0.6

Table I

loss would remain approximately constant since these effects would counteract one another. That is, the deepening layer depth would decrease the loss while the less intense below layer gradient increased the loss.

In contrast, at 1000 HZ, 150 FT layer depth, and 4°/100 FT gradient, the change due to changing layer depth is 3 times the change due to changing below layer gradient. Thus under these circumstances, a change in layer depth of 25 FT is equivalent to a change of 6°F/100 FT below layer gradient.

The change due to frequency is most significant at lower frequencies, particularly at relatively shallow layer depths. For example, the frequency gradient at 100 HZ is 5 times greater than the frequency gradient at 1000 HZ in regions where the layer depth is close to the minimum required for ducting. As previously noted, the change due to increasing sea state steadily increases with frequency with a relatively minor effect due to layer depth. Over the range of 100 HZ to 2000 HZ, it can be seen that the loss increases by a factor of approximately 6 due to an increase in frequency. When the frequency is held constant, the change in loss due to layer depth change varies by a factor of roughly 2 over the range considered.

In summary, change frequency and layer depth have the greatest effect on transmission loss over the range from 300 to 2400 HZ. Below 300 HZ, particularly where conditions for ducting are marginal, the below layer thermal gradient

can have an appreciable effect on the amount of propagation loss encountered. Under marginal ducting conditions, it was found that for low frequencies, a 25 FT change in layer depth had the same resultant effect on the loss gradient as a change in gradient of 2°F/100 FT. An increase in sea state was found to increase the amount of loss at all points within the domain with the largest change occurring at higher frequencies. It was noted that this loss varied by a factor of 6 over the frequency range of 100 to 2400 HZ while it varied by a factor of 2 over the layer depth range of 50 to 750 FT. Finally, the non-range dependent term associated with the effective layer depth is wholly dependent upon layer depth. This parameter was found to be approximately 8 times more sensitive at shallow layer depths when compared to deep layer depths for the range of depths considered.

V. APPLICATION TO THE TACTICAL PROBLEM

Adapting to changing environmental conditions is perhaps one of the most important problems in anti-submarine warfare (ASW) today. This is particularly apparent in passive detection. Submarine acoustic source levels have steadily decreased as technology has advanced while the amount of loss suffered by these signals has remained constant for a given set of environmental conditions. The net result is a much smaller difference between sound emitted and sound received. With the advent of ASRAP came the ability to predict, within specified statistical limits, the amount of loss which a signal would undergo as a function of range, frequency, and various environmental parameters. The weekly time interval between forecasts makes it tactically prudent and operationally necessary to update these forecasts whenever the resultant change in the propagation loss parameter becomes significant.

To perform the updating of an ASRAP forecast, the information available "On-Station" must first be defined, then measured, and then finally applied in the form of a correction algorithm. The source frequency of interest may be obtained either from intelligence information or from actual detections currently under investigation. Remaining to be defined and measured are the environmental parameters of layer depth, below layer gradient, and sea state. Layer depth and the below layer thermal gradient are obtainable from an airborne

expendable bathythermograph (AXBT) trace. The sea state is obtained either from direct visual observation or, in the event of cloud cover or darkness, by noting the amount of sonobuoy transmission interference due to waves overwashing the sonobuoy and thereby interrupting the radio transmission ("wash-over"). Utilizing these parameters, it is possible to develop a correction algorithm to be employed in conjunction with the equations previously developed to perform the desired updating function. This will allow for the correction of forecast propagation loss when ducting conditions are present.

The first step in this updating procedure is to ascertain if the change in propagation loss due to changing environmental conditions is significantly different from that forecast. That is, will the resulting change in propagation loss significantly alter the tactical problem to an extent where updating of the forecast is warranted. The question of what is significant must first be answered. This concept of significance is highly relative and may vary from one tactical problem to another. For instance, a 10% change in the propagation loss may be significant in one tactical situation and yet not be deemed significant in another. Because of this relative nature, a general method will be developed to yield a reference parameter which can be utilized as a guideline for individual situation judgements as to significance. This guideline parameter is the amount of propagation loss change at a range of 10 NM and is denoted

by ΔL_{10}. This reference parameter will serve as a common point or a reference frame upon which further decisions can be based. By utilizing the tables and/or graphs presented in Appendix A, the following step-by-step procedure can be utilized to determine ΔL_{10}:

1. Determine if the ducted mode of propagation is likely to exist by finding the cut-off layer depth present for the frequency of interest. Table A-1 can be utilized for this purpose.

2. If ducting is present, determine the amount of change due to the effective layer loss term (due to changing layer depth) by subtracting the loss at the forecast layer depth from the loss at the layer depth present on-station.

3. From the table in Appendix A corresponding to the predicted sea state and the closest forecast frequency (100,300,850, or 1700 HZ), determine the forecast duct loss term by entering the table at the predicted layer depth and below layer thermal gradient.

4. Determine the on-station duct loss term by entering the table which corresponds to the actual sea state present and the closest frequency desired with the layer depth and below layer thermal gradient determined from the AXBT.

5. Determine the change in duct loss by subtracting the results of step (4) from the results of step (3).

6. To determine the change in propagation loss at a range of 10 NM, ΔL_{10}, algebraically add the results of step (2) to 10 times the results of step (5).

Several examples of this procedure follow:

Example 1:

Forecast Conditions	On-Station Conditions
850 HZ	1000 HZ
250 FT layer depth	150 FT layer depth
-6°F/100 FT gradient	-10°F/100 FT gradient
Low sea state	High sea state

1. From Table A-1, a 250 FT layer will duct frequencies higher than 273 HZ and a 150 FT layer will duct frequencies higher than 588 HZ. It can be assumed that under these conditions, both the forecast and the on-station conditions will permit a ducted mode of propagation.

2. From Table A-1, the effective layer loss change is determined by

Effective layer loss$_{(250\ FT)}$:	32.9 dB
Effective layer loss$_{(150\ FT)}$:	31.8 dB
Change	+ 1.1 dB

3. Duct loss predicted conditions from Table A-12, 900 HZ,250 FT, -6°F/100 FT, low sea state: 0.8 dB/NM.

4. Duct loss on-station conditions from Table A-37, 1000 HZ, 150 FT, -10°F/100 FT, high sea state: 2.1 dB/NM.

5. Change in duct loss is given by

Forecast:	0.8 dB/NM
On-Station:	2.1 dB/NM
Change	- 1.3 dB/NM.

6. The change in propagation loss at a range of 10 NM is

   Effective layer loss change: + 1.1 dB

   10 x duct loss change: 10 x (-1.3) = -13.0 dB

   Change at 10 NM, ΔL_{10} = 1.1 + (-13.0) = <u>-11.9 dB</u>

   In this example, under the actual conditions, the loss is 11.9 dB GREATER than that under the predicted conditions.

Example 2:

Forecast Conditions	On-Station Conditions
300 HZ	500 HZ
300 FT layer	250 FT layer
-10°F/100 FT gradient	-12°F/100 FT gradient
Low sea state	Low sea state

1. From Table A-1, the cut-off frequency for a 300 FT layer depth is 208 HZ. For a 250 FT layer depth, the cut-off is 273 HZ. Conditions are present for ducting under both the predicted and the on-station conditions.

2. From Table A-1, the change in the effective layer loss is

   Effective layer loss$_{(300)}$: 33.3 dB

   Effective layer loss$_{(250)}$: 32.9 dB

   Change + 0.4 dB

3. From Table A-6, the forecast duct loss term is

   300 HZ, 300 FT, -10°F/100 FT, low sea state: 0.8 dB/NM.

4. The duct loss under the on-station conditions is found from Table A-8 to be

   500 HZ,250 FT, -12°F/100 FT, low sea state: 0.8 dB.

5. The change in the duct loss is then

Forecast:	0.8 dB/NM
On-Station:	0.8 dB/NM
Change:	0.0 dB

6. The change in propagation loss at 10 NM, ΔL_{10}, is

Effective layer loss change: 0.4 dB

10 x duct loss change: 10 x (0.0) = 0.0 dB

Change at 10 NM, ΔL_{10} = + 0.4 dB

In this example, there was 0.4 dB LESS loss under the actual conditions than under the forecast conditions.

Example 3:

Forecast Conditions	On-Station Conditions
1700 HZ	2000 HZ
225 FT layer	75 FT layer
-12°F/100 FT gradient	-4°/100 FT gradient
High sea state	Low sea state

1. From Table A-1, it can be seen that the cut-off frequency for the shallower layer depth is lower than either the closest forecast frequency or the frequency of interest, that ducting will be present in both situations.

2. From Table A-1, the change in the effective layer loss term is found as,

Effective layer loss$_{(225)}$:	32.7 dB
Effective layer loss$_{(75)}$:	30.3 dB
Change	+ 2.4 dB

3. From Table A-44, the duct loss under the forecast conditions is given as

   1700 HZ,225 FT, -12°F/100 FT, high sea state: 1.8 dB/NM.

4. The duct loss for the on-station conditions is found from Table A-23 to be

   2000 HZ,75 FT, -4°F/100 FT, low sea state: 3.6 dB/NM.

5. The change in the duct loss term is

   Forecast: 1.8 dB/NM

   On-Station: 3.6 dB/NM

   Change: - 1.8 dB/NM

6. The parameter ΔL_{10} is found as

   Effective layer loss change: + 2.4 dB

   10 x Duct loss change 10 x (-1.8) = -18.0 dB

   Change at 10 NM, ΔL_{10} = <u>-15.6 dB.</u>

   Under these circumstances, there was 15.6 dB MORE loss on-station than forecast at a range of 10 NM.

Example 4:

Forecast Conditions	On-Station Conditions
850 HZ	1000 HZ
250 FT	No Layer
-6°F/100 FT	-6°F/100 FT
Low sea state	Low sea state

1. From Table A-1, ducting is likely under the forecast conditions. No ducting is possible under the on-station conditions.

2. The change in the propagation loss at 10 NM, ΔL_{10}, is given by

Forecast ducted loss - (On-station non-ducted loss)

Forecast loss at 10 NM:

Effective layer loss	=	32.9 dB
Spreading loss	=	43.0 dB
Duct loss	=	8.0 dB
Total Forecast		83.9 dB

On-station Loss at 10 NM (from Table A-2):

Spreading loss	=	86.0 dB
Absorption loss	=	1.0 dB
Total On-station	=	87.0 dB

$\Delta L_{10} = 83.9 - 87.0 = \underline{-3.1 \text{ dB}}$

In this example there was 3.1 dB MORE loss under the on-station conditions than under the forecast conditions. It must be stressed that this is an approximate solution for the non-ducted case and that the actual loss encountered may vary to some extent from the solution obtained.

The value which one assigns to the parameter ΔL_{10} as a critical value is, for the most part, arbitrary. That is, the point at which an on-station update will be performed due to the arbitrary limit on ΔL_{10} being exceeded will again be dependent upon the tactical situation. As a rule of thumb, the value of ±6dB can be utilized. This value has statistical significance since this value is normally utilized as the standard deviation for the Figure of Merit

equation.[2] Thus, if the forecast and on-station propagation losses vary by more than ± 6 dB, an updating of the propagation loss would be required when applying the above rule of thumb.

Once it has been established that the updating of a propagation loss profile is advisable, the following step-by-step procedure can be used in conjunction with the worksheet shown in Figure 18.

1. Determine if ducting is likely under the on-station conditions. Recall, that the low-frequency cut-off for a given duct size is not sharply defined and that ducting may occur at shallower layer depths. In the computational procedure used to derive the tables and graphs depicted in Appendix A, ducting was permitted at frequencies as low as 0.7 F_{low}. If ducting is not likely, follow the procedure delineated in steps 7-8.
2. For ducted cases, determine the loss due to the effective layer spreading by entering Table A-1 with the on-station layer depth.
3. Determine the ducted spreading loss from Table A-2 at the desired range intervals.
4. Determine the duct loss at the desired ranges by multiplying the range (NM) and the loss (dB/NM) found by entering the appropriate table in Appendix A which

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[2] The Figure of Merit equation is given as

$$FOM = SL - AN - RD + DI = \text{propagation loss}$$

where SL is the source level, AN is the ambient noise, RD is the recognition differential, and DI is the directivity index (NAVWEASERVCOMINST 3160.3).

FORECAST BT______*______*______*______*______*______*

ON-STA. BT______*______*______*______*______*______*

FORECAST CONDITIONS	ON-STATION CONDITIONS
Frequency______HZ	Frequency______HZ
Sea State__________	Sea State__________
Layer Depth______FT	Layer Depth______FT
Gradient______°F/100 FT	Gradient______°F/100 FT
Cut-Off Freq.______HZ	Cut-Off Freq.______HZ
Ducted_____Non-Ducted_____	Ducted_____Non-ducted___

<u>Ducted Case</u>

Effective Layer Loss______Db

Cross-Layer Loss ______Db

Total Fixed Losses ______Db

<u>Non-Ducted Case</u>

Absorption Loss

______Db/NM

Range						
Fixed Losses						
Spreading Loss						
Duct Loss						
Total Losses						

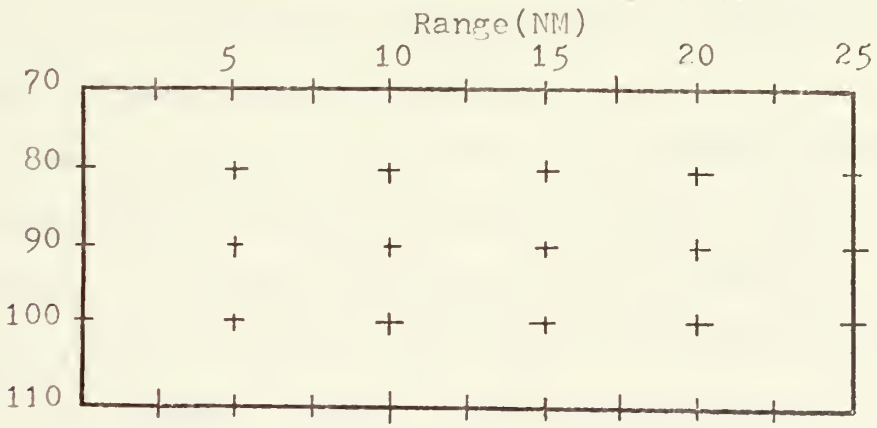


Figure 18. A worksheet for determining on-station propagation loss.

corresponds to the desired frequency, for the sea state present at the layer depth and below layer thermal gradient from the AXBT trace.

5. If cross-layer conditions are present, add 10 dB.
6. The propagation loss at a given range R is found by

   Propagation Loss (dB) = Effective Layer Loss + Ducted Spreading Loss (at R) + R x (Duct Loss) + Cross-Layer Loss (if present).
7. If ducting is not present, the only losses which can be readily determined are the non-ducted (spherical) spreading loss and the frequency dependent absorption loss. From Table A-2, determine the spreading loss at any range R. The absorption loss (dB/NM) can also be found from Table A-2.
8. To determine the approximate non-ducted propagation loss at a range R,

   Propagation Loss (dB) = Non-ducted Spreading Loss + R x (Absorption Loss).

   It should be noted again that this solution is not exact and may be dependent upon multi-path transmissions as well as phase coherence effects.

To further examine the effects of changing environmental conditions on the tactical problem, several examples will be utilized. Consider the case given in Example 1. In this example, the layer depth, below layer thermal gradient, sea state and frequency differed from the conditions which were forecast. Figure 19 depicts the forecast and on-station

EXAMPLE 1

FORECAST BT______*______*______*______*______*______*

ON-STA. BT______*______*______*______*______*______*

FORECAST CONDITIONS

Frequency 850 HZ

Sea State LOW

Layer Depth 250 FT

Gradient -6 °F/100 FT

Cut-Off Freq. 273 HZ

Ducted x Non-Ducted ____

Ducted Case

Effective Layer Loss 31.8 Db

Cross-Layer Loss 0 Db

Total Fixed Losses 31.8 Db

ON-STATION CONDITIONS

Frequency 1000 HZ

Sea State HIGH

Layer Depth 150 FT

Gradient -10 °F/100 FT

Cut-Off Freq. 588 HZ

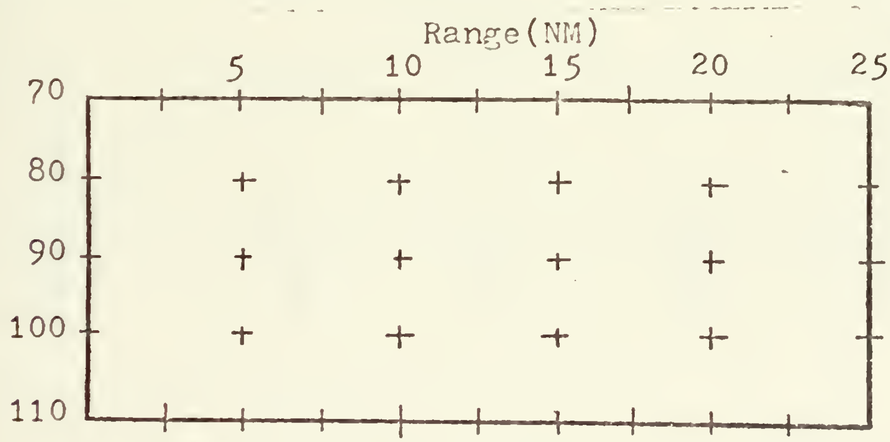
Ducted x Non-ducted ___

Non-Ducted Case

Absorption Loss

____ Db/NM

Range	1	3	5	10	15	
Fixed Losses	31.8	31.8	31.8	31.8	31.8	
Spreading Loss	33.0	37.8	40.0	43.0	44.0	
Duct Loss	2.1	6.3	10.5	21.0	31.5	
Total Losses	66.9	77.9	82.3	95.8	108.1	



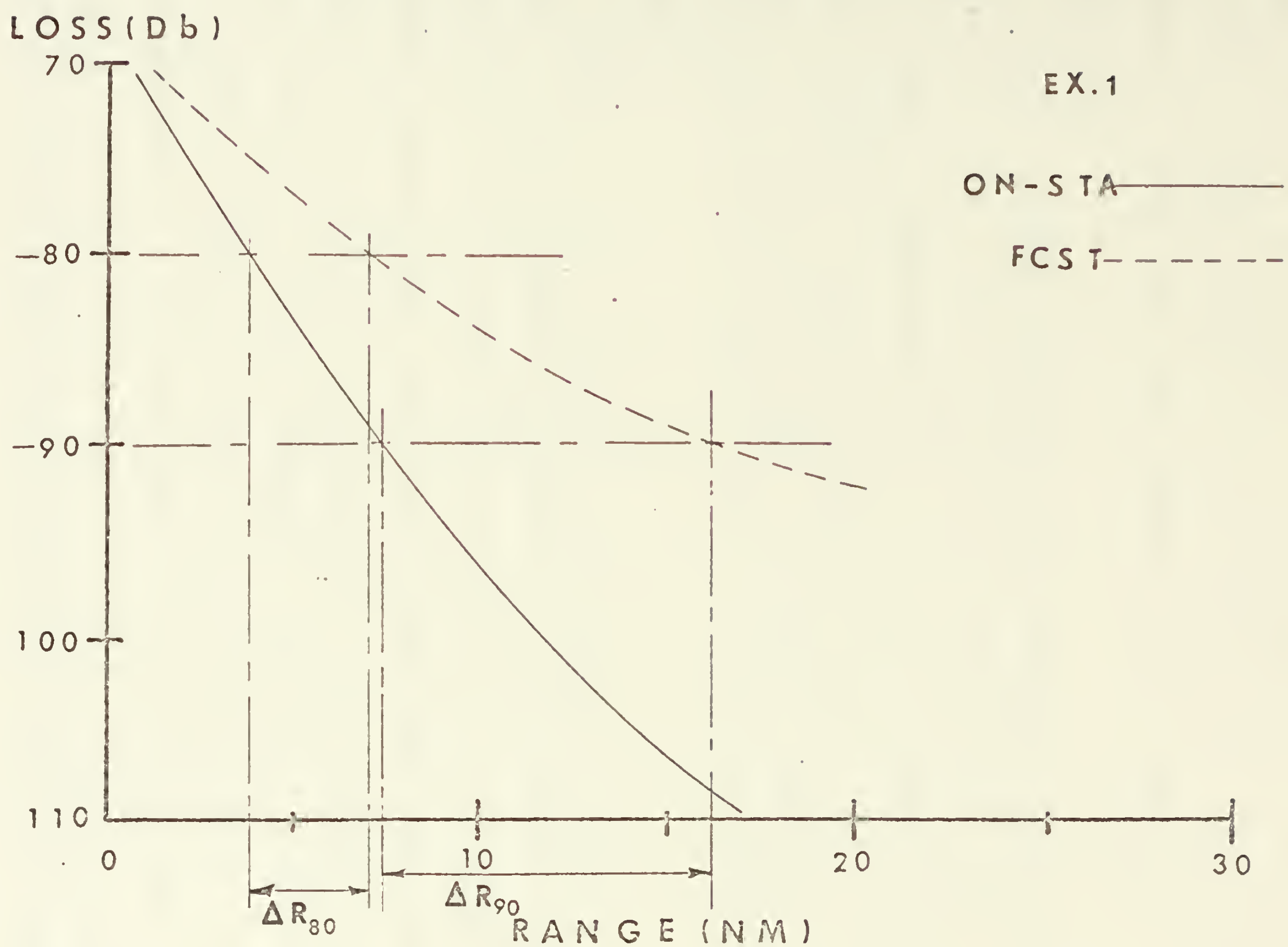


Figure 19. Solution to Example 1. Range differences are shown for 80 and 90 dB figures of merit.

propagation loss profiles resulting under these conditions. As previously noted, ΔL_{10} is 11.9 dB. For a 90 dB FOM, this results in a decrease in the Median Detection Range (MDR)[3] from 15 NM forecast to 8 NM on-station. For an 80 dB FOM, the MDR decreases from 7 NM to 4 NM. Under common operating situations, this change would be considered significant.

Example 2 gave an example where changing on-station conditions were, to a large extent, offsetting. That is, the change in layer depth was offset by a change in below layer gradient. Since the parameter ΔL_{10} is small (0.4 dB), there is no need under these conditions to update the ASRAP propagation loss forecast. Figure 20 illustrates this example.

Example 3 gave conditions which might be likely to exist if heavy weather had existed at the time the forecast was issued. The on-station conditions, at a time after the weather had subsided, are much different than when forecast. Figure 21 illustrates the propagation loss profiles under the forecast and actual on-station conditions. Taking a 90 dB FOM, the MDR was reduced from 9 NM to 5.5 NM. For an 80 dB FOM, the MDR was reduced from 5 NM to 3 NM. The case of a 90 dB FOM would most likely be considered significant for normal operating circumstances while the change for

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[3]The Median Detection Range is that range for which there is a probability of detection of 0.5 using the FOM equation.

EXAMPLE 2

FORECAST BT______*______*______*______*______*______*

ON-STA. BT______*______*______*______*______*______*

FORECAST CONDITIONS

Frequency 300 HZ

Sea State LOW

Layer Depth 300 FT

Gradient -10 °F/100 FT

Cut-Off Freq. 208 HZ

Ducted x Non-Ducted ____

Ducted Case

Effective Layer Loss 32.9 Db

Cross-Layer Loss 0 Db

Total Fixed Losses 32.9 Db

ON-STATION CONDITIONS

Frequency 500 HZ

Sea State LOW

Layer Depth 250 FT

Gradient -12 °F/100 FT

Cut-Off Freq. 273 HZ

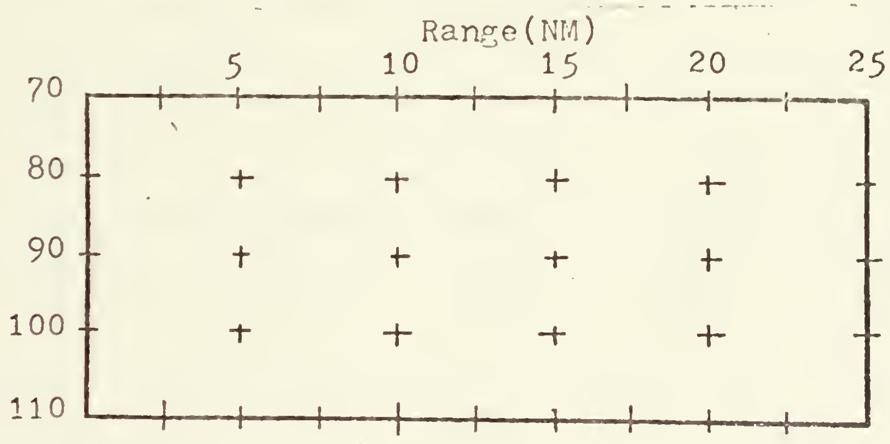
Ducted x Non-ducted ___

Non-Ducted Case

Absorption Loss

____ Db/NM

Range	1	3	5	10	15	
Fixed Losses	32.9	32.9	32.9	32.9	32.9	
Spreading Loss	33.0	37.8	40.0	43.0	44.8	
Duct Loss	0.8	2.4	4.0	8.0	12.0	
Total Losses	66.7	73.1	76.9	83.9	89.7	



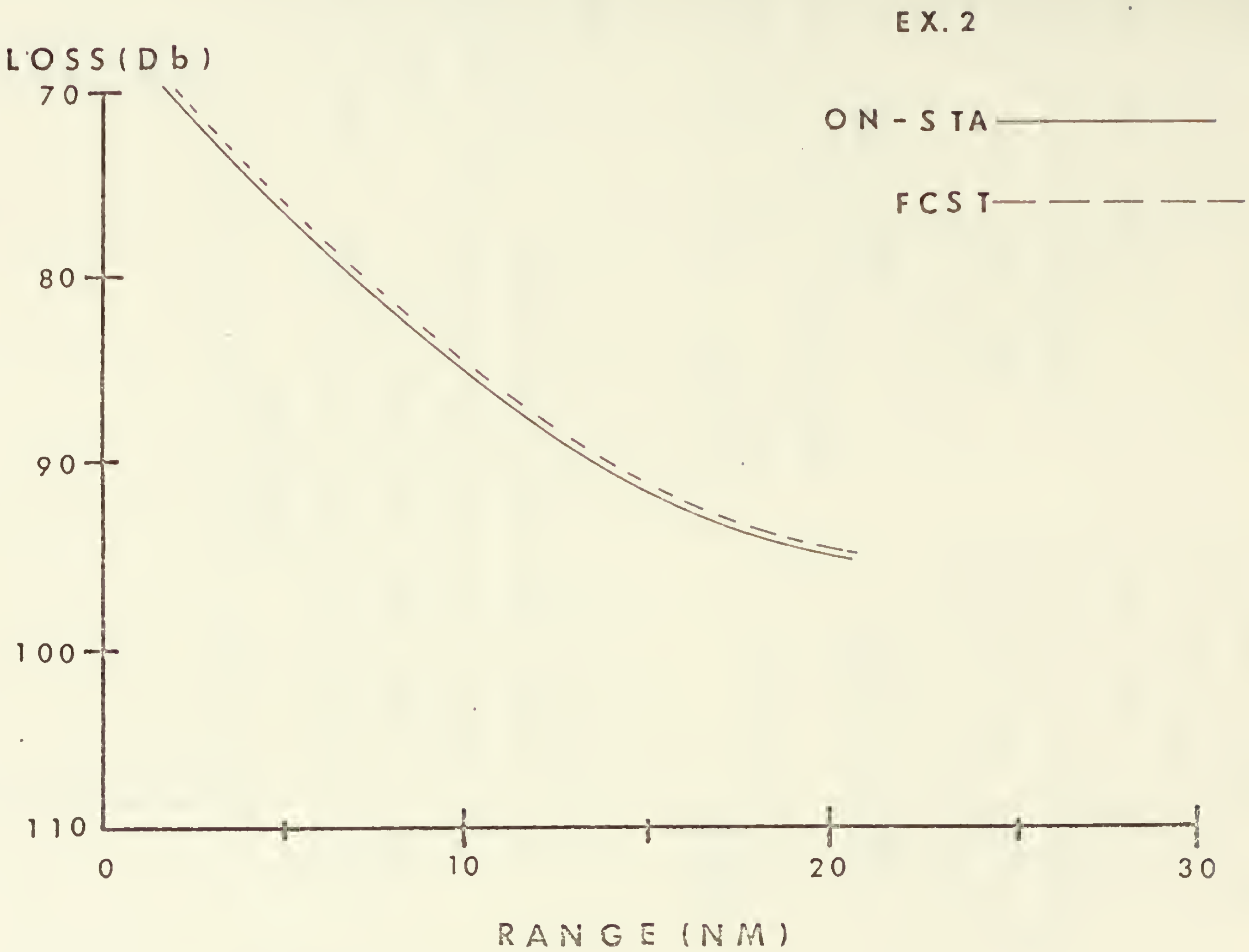


Figure 20. Solution to Example 2.

EXAMPLE 3

FORECAST BT______*______*______*______*______*______*

ON-STA. BT______*______*______*______*______*______*

FORECAST CONDITIONS

Frequency 1700 HZ

Sea State HIGH

Layer Depth 225 FT

Gradient -12 °F/100 FT

Cut-Off Freq. 320 HZ

Ducted x Non-Ducted______

Ducted Case

Effective Layer Loss 30.3 Db

Cross-Layer Loss 0 Db

Total Fixed Losses 30.3 Db

ON-STATION CONDITIONS

Frequency 2000 HZ

Sea State LOW

Layer Depth 75 FT

Gradient -4 °F/100 FT

Cut-Off Freq. 1663 HZ

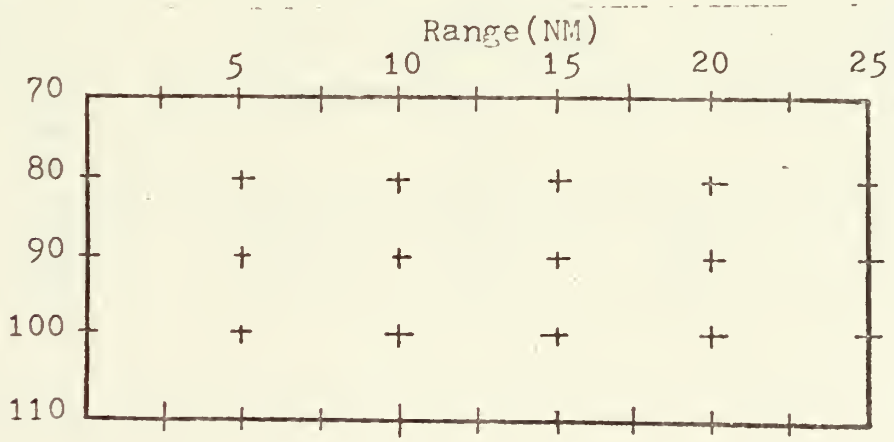
Ducted x Non-ducted___

Non-Ducted Case

Absorption Loss

______Db/NM

Range	1	3	5	10	15	
Fixed Losses	30.3	30.3	30.3	30.3	30.3	
Spreading Loss	33.0	37.8	40.0	43.0	44.8	
Duct Loss	3.6	10.8	18.0	36.0	54.0	
Total Losses	66.9	78.9	88.3	109.3	129.1	



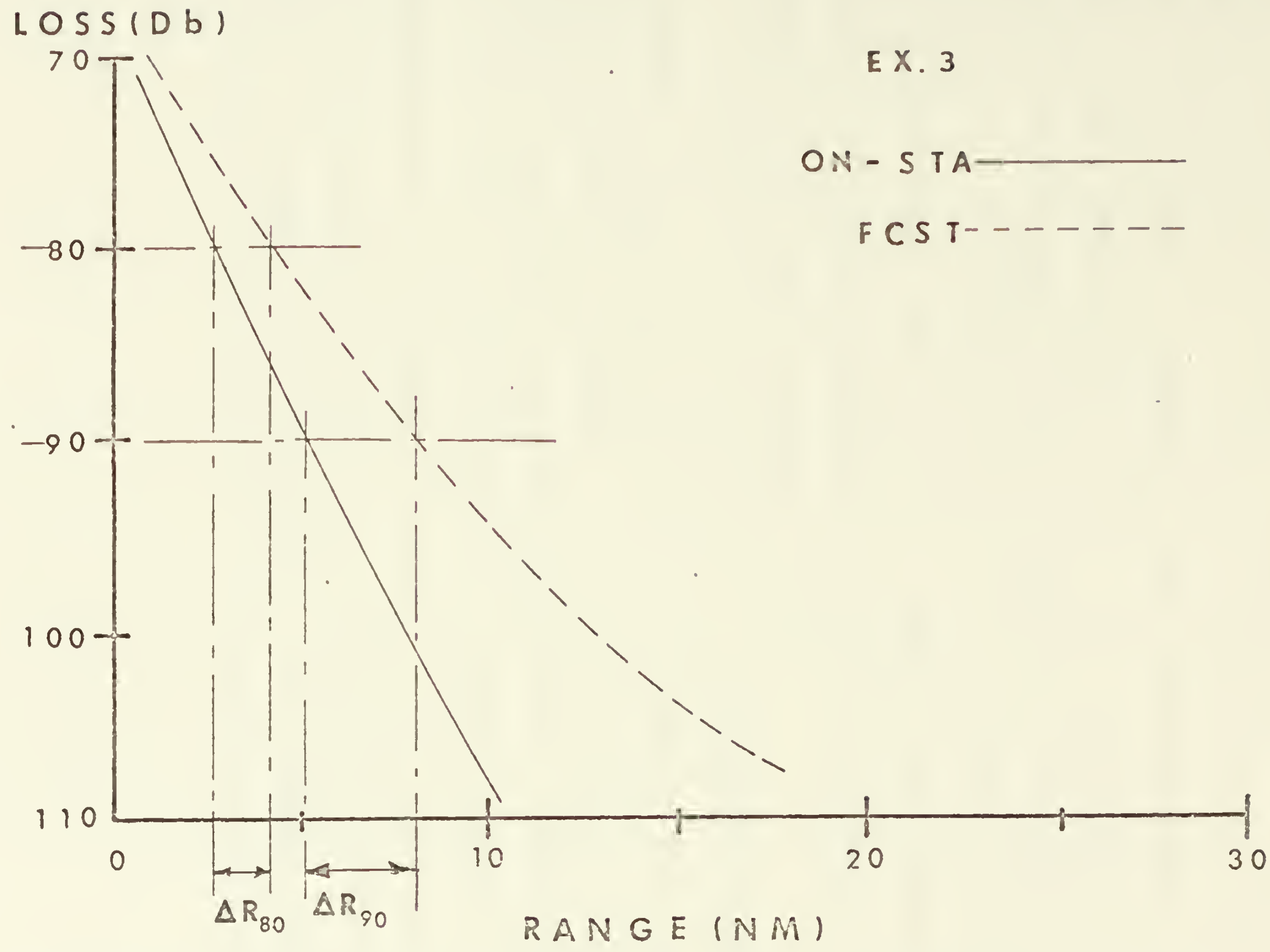


Figure 21. Solution to Example 3. Range differences shown are for 80 and 90 dB figures of merit.

the 80 dB case might not be considered significant under some operating conditions.

Example 4 illustrates the case where ducting conditions were forecast but on-station conditions dictated that no ducting was possible. Figure 22 illustrates this situation. When a 90 dB FOM is considered, the resulting change in MDR is 2 NM, from 15 NM to 13 NM. The same change in MDR is also evident when the FOM is taken as 80 dB since the forecast and on-station profiles tend to differ by similar amounts over this range interval. Again, the non-ducted solution is only an approximation but this estimate is perhaps better than no estimate at all.

In summary, it is now possible to determine a reference parameter, ΔL_{10}, which will aid in determining if an update of the forecast is required. As a rule of thumb, if ΔL_{10} differs by more than one standard deviation (normally taken as 6 dB), then an update should be performed. Once it is determined that an update is desired, it may be accomplished by determining the different loss values involved from tables or graphs listed in Appendix A and summing these loss values in accordance with the correction algorithm.

EXAMPLE 4

FORECAST BT______*______*______*______*______*______*

ON-STA. BT______*______*______*______*______*______*

FORECAST CONDITIONS

Frequency 850 HZ

Sea State LOW

Layer Depth 250 FT

Gradient -6 °F/100 FT

Cut-Off Freq. 273 HZ

Ducted x Non-Ducted ____

Ducted Case

Effective Layer Loss ____ Db

Cross-Layer Loss ____ Db

Total Fixed Losses ____ Db

ON-STATION CONDITIONS

Frequency 1000 HZ

Sea State LOW

Layer Depth 0 FT

Gradient -6 °F/100 FT

Cut-Off Freq. N/A HZ

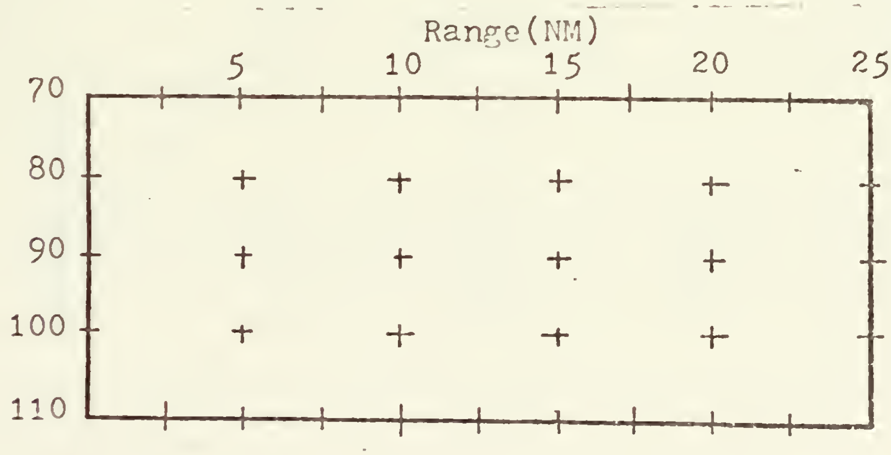
Ducted ____ Non-ducted x

Non-Ducted Case

Absorption Loss

0.1 Db/NM

Range	1	3	5	10	15	20
Fixed Losses	--	--	--	--	--	--
Spreading Loss	66.0	75.5	80.0	86.0	89.5	92.0
Absorption	0.1	0.3	0.5	1.0	1.5	2.0
Total Losses	66.1	75.8	80.5	87.0	91.0	94.0



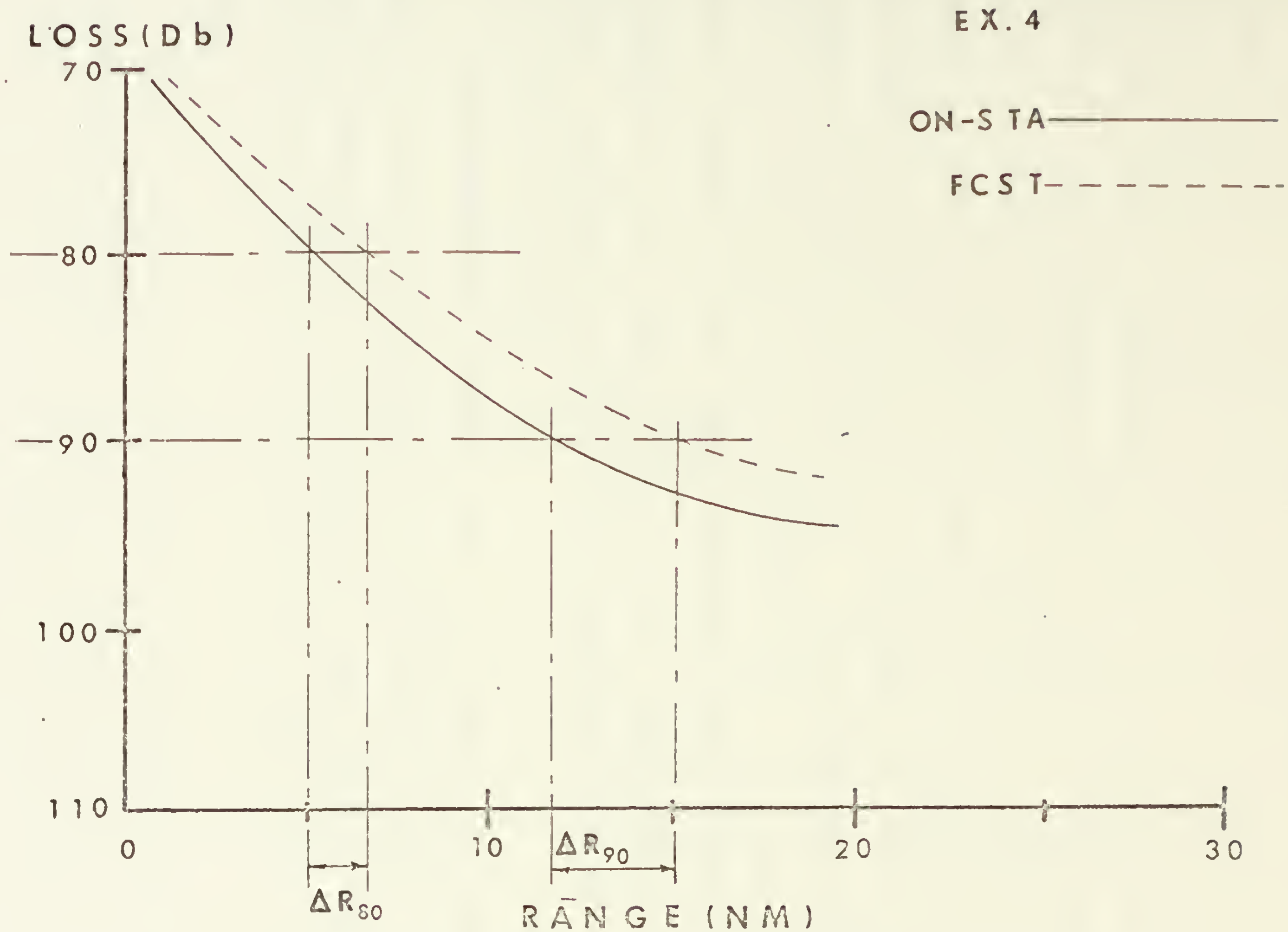


Figure 22. Solution for Example 4. Range differences are for 80 and 90 dB figures of merit.

VI. CONCLUSIONS

The model for low frequency ducted propagation loss consisted of the specification and determination of the losses encountered within a surface duct. These losses resulted from the reduction of power per unit area due to spreading and attenuation within the duct. The spreading loss is comprised of spherical spreading to a transition range and the cylindrical spreading at all greater ranges. The spherical spreading loss is accounted for in the loss termed the effective layer loss. The cylindrical spreading loss is termed the ducted spreading loss. The attenuation term consisted of the losses associated with diffractive leakage of sonic energy from the duct, scattering of energy from a roughened sea surface, and absorption due to relaxation mechanisms.

The sensitivity of this model was found to be dependent upon the governing parameters which specify the loss terms. These parameters are the frequency, layer depth, sound velocity gradients above and below the layer, and the sea state.

Over a relatively wide range of the domain investigated, the frequency and layer depth were found to have the greatest effect on the amount of propagation loss encountered. Over those portions of the domain which lie near the conditions required for the ducting of sonic energy, the below layer gradient has an appreciable effect. For example, within this

region of marginal ducting conditions, a below layer thermal gradient change of 2°F/100 FT was found to have the same effect on the resulting propagation loss as a change in the mixed layer depth of 25 FT. In contrast, in areas away from this region, the loss becomes more independent of the below layer gradient. In some areas, a change of 18°F/100 FT results in a negligible change in propagation loss (less than 0.1 dB/NM). The change in loss due to a change in frequency is most intense at low frequencies and relatively shallow layer depths. This loss gradient was found to be as much as 5 times more intense at 100 HZ than at 1000 HZ under comparable environmental conditions.

An increase in the sea state was found to cause an increase in the amount of loss resulting at all locations within the domain of interest. The amount of increase in propagation loss varied as a function of frequency and layer depth. The magnitude of this change ranged from several tenths of a dB/NM at lower frequencies to approximately 1 dB/NM at higher frequencies. Frequency was found to have the most effect upon this change and varied by a factor of 6 over the range investigated. The change in loss was found to vary by a factor of 2 as a function of the layer depth when the sea state increased.

The change in loss due to the transition range or the effective layer loss was found to be dependent upon the mixed layer depth when simplifying assumptions were imposed regarding the above layer gradient and target location within the

vertical dimension of the surface duct. The resulting change in propagation loss was found to be approximately 8 times more sensitive to change in mixed layer depth over shallow intervals as compared to the deeper intervals.

The amount of change in ducted propagation loss due to changing environmental conditions is dependent not only upon the magnitude of the change but also upon the location within the frequency-sound velocity gradient-sea state domain at which the change occurs. That is, the resultant change in loss is dependent upon the magnitude of the changes in the environmental parameters, the location within the domain from which such changes originate, and the direction in which the changes proceed.

The value of change in propagation loss which constitutes significance is relative to the tactical situation under consideration. In one instance, a 6 dB change at some specified range may be significant while in another instance, it may be deemed negligible. This apparent ambiguity can be best approached by permitting the significance decision to be made within the context of the actual situation at hand. To aid in this decision, the reference parameter ΔL_{10}, the change in propagation loss encountered under actual conditions from that which was forecast for a range of 10 NM from the source, was developed. As a rule-of-thumb, if ΔL_{10} exceeds one standard deviation (taken to have a nominal value of 6 dB), the forecast should be updated when possible.

The correction algorithm for the ducted propagation case is compatible with the method currently employed by the FNWC since identical models and equations are utilized. The ability to update this form of propagation loss is extremely important when the near field or direct path situation is considered. Additionally, this method can be employed to enhance the accuracy of forecast propagation loss in cases where the actual and predicted environmental conditions are identical since this method allows for a more finite interpolation within the frequency domain.

There is much to be done in the field of ASRAP update, particularly in the area of non-ducted propagation cases. It is hoped that the methods employed here will aid in furthering this effort.

Appendix A. Supplemental Graphs and Tables

Table A-1

FREQUENCY CUT-OFF AND EFFECTIVE LAYER CORRECTION

LAYER(FT)	CUT-OFF FREQUENCY(HZ)	EFFECTIVE LAYER LOSS(DB)
50.0	3054.7	29.4
75.0	1662.8	30.3
100.0	1080.0	30.9
125.0	772.8	31.4
150.0	587.9	31.8
175.0	466.5	32.2
200.0	381.8	32.4
225.0	320.0	32.7
250.0	273.2	32.9
275.0	236.8	33.1
300.0	207.8	33.3
325.0	184.3	33.5
350.0	164.9	33.7
375.0	148.7	33.8
400.0	135.0	34.0
425.0	123.3	34.1
450.0	113.1	34.2
475.0	104.3	34.3
500.0	96.6	34.4
525.0	89.8	34.5
550.0	83.7	34.6
575.0	78.3	34.7
600.0	73.5	34.8
625.0	69.1	34.9
650.0	65.2	35.0
675.0	61.6	35.1
700.0	58.3	35.2
725.0	55.3	35.2
750.0	52.6	35.3

Table A-2.

SPREADING LOSS/DUCTED CASES

RANGE(NM) LOSS(DB)

RANGE	LOSS	RANGE	LOSS	RANGE	LOSS	RANGE	LOSS	RANGE	LOSS
1.0	33.0	11.0	43.4	21.0	46.2	31.0	47.9	41.0	49.1
2.0	36.0	12.0	43.8	22.0	46.4	32.0	48.1	42.0	49.2
3.0	37.8	13.0	44.1	23.0	46.6	33.0	48.2	43.0	49.3
4.0	39.0	14.0	44.5	24.0	46.8	34.0	48.3	44.0	49.4
5.0	40.0	15.0	44.8	25.0	47.0	35.0	48.4	45.0	49.5
6.0	40.8	16.0	45.0	26.0	47.1	36.0	48.6	46.0	49.6
7.0	41.5	17.0	45.3	27.0	47.3	37.0	48.7	47.0	49.7
8.0	42.0	18.0	45.6	28.0	47.5	38.0	48.8	48.0	49.8
9.0	42.5	19.0	45.8	29.0	47.6	39.0	48.9	49.0	49.9
10.0	43.0	20.0	46.0	30.0	47.8	40.0	49.0	50.0	50.0

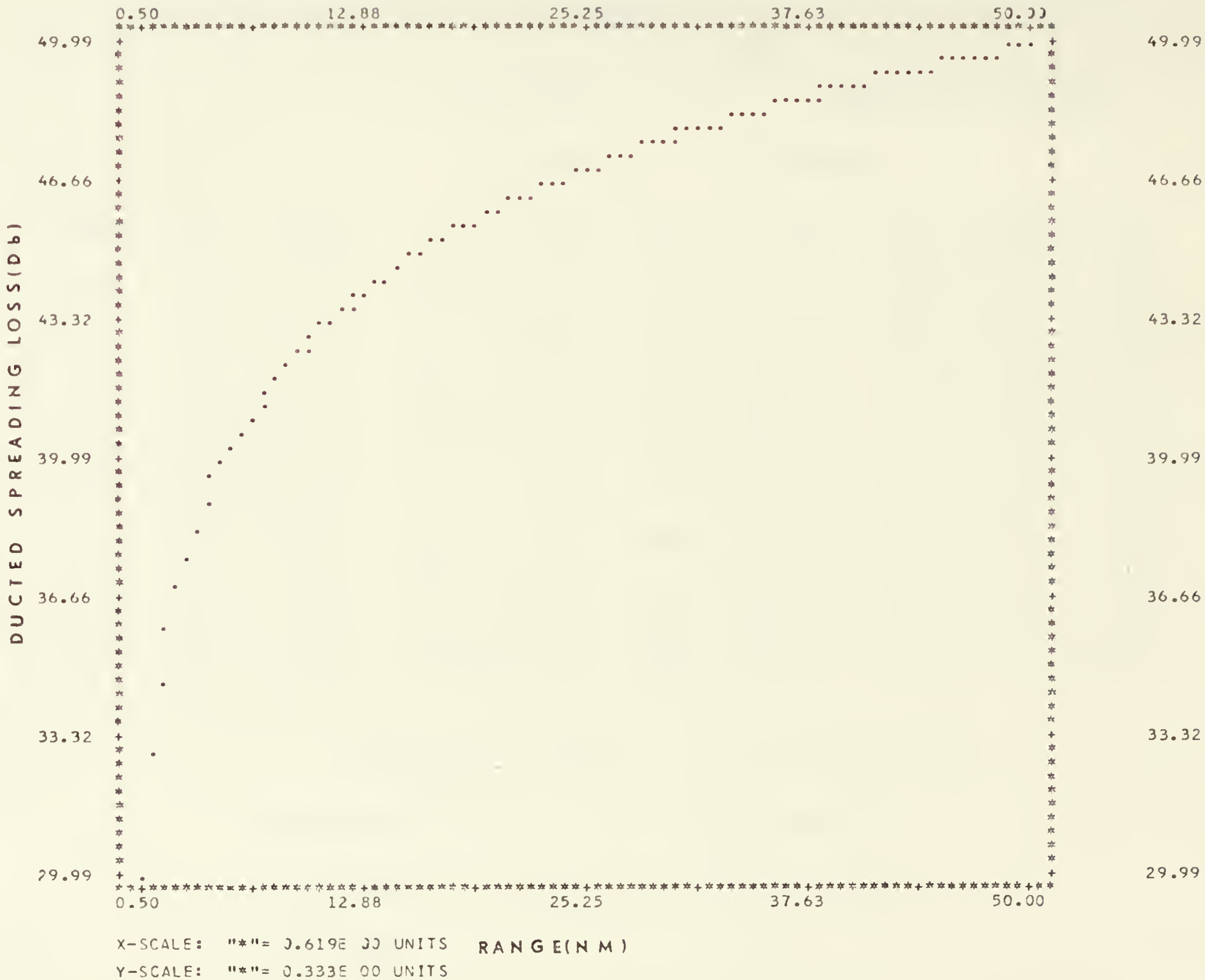


Figure A-1. Ducted (cylindrical) spreading loss as a function of range.

Table A-3

SPREADING LOSS / NON-DUCTED CASES

RANGE(NM) LOSS(DB)

RANGE	LOSS	RANGE	LOSS	RANGE	LOSS	RANGE	LOSS	RANGE	LOSS
1.0	66.0	11.0	86.8	21.0	92.4	31.0	95.8	41.0	98.3
2.0	72.0	12.0	87.6	22.0	92.8	32.0	96.1	42.0	98.5
3.0	75.5	13.0	88.3	23.0	93.2	33.0	96.4	43.0	98.7
4.0	78.0	14.0	88.9	24.0	93.6	34.0	96.6	44.0	98.9
5.0	80.0	15.0	89.5	25.0	94.0	35.0	96.9	45.0	99.1
6.0	81.6	16.0	90.1	26.0	94.3	36.0	97.1	46.0	99.3
7.0	82.9	17.0	90.6	27.0	94.6	37.0	97.4	47.0	99.4
8.0	84.1	18.0	91.1	28.0	94.9	38.0	97.6	48.0	99.6
9.0	85.1	19.0	91.6	29.0	95.2	39.0	97.8	49.0	99.8
10.0	86.0	20.0	92.0	30.0	95.5	40.0	98.0	50.0	100.0

ABSORBTION LOSS / NON-DUCTED CASES

FREQUENCY(HZ)	LOSS(DB/NM)
100-500	0.0
500-2000	0.1
2000-2400	0.2

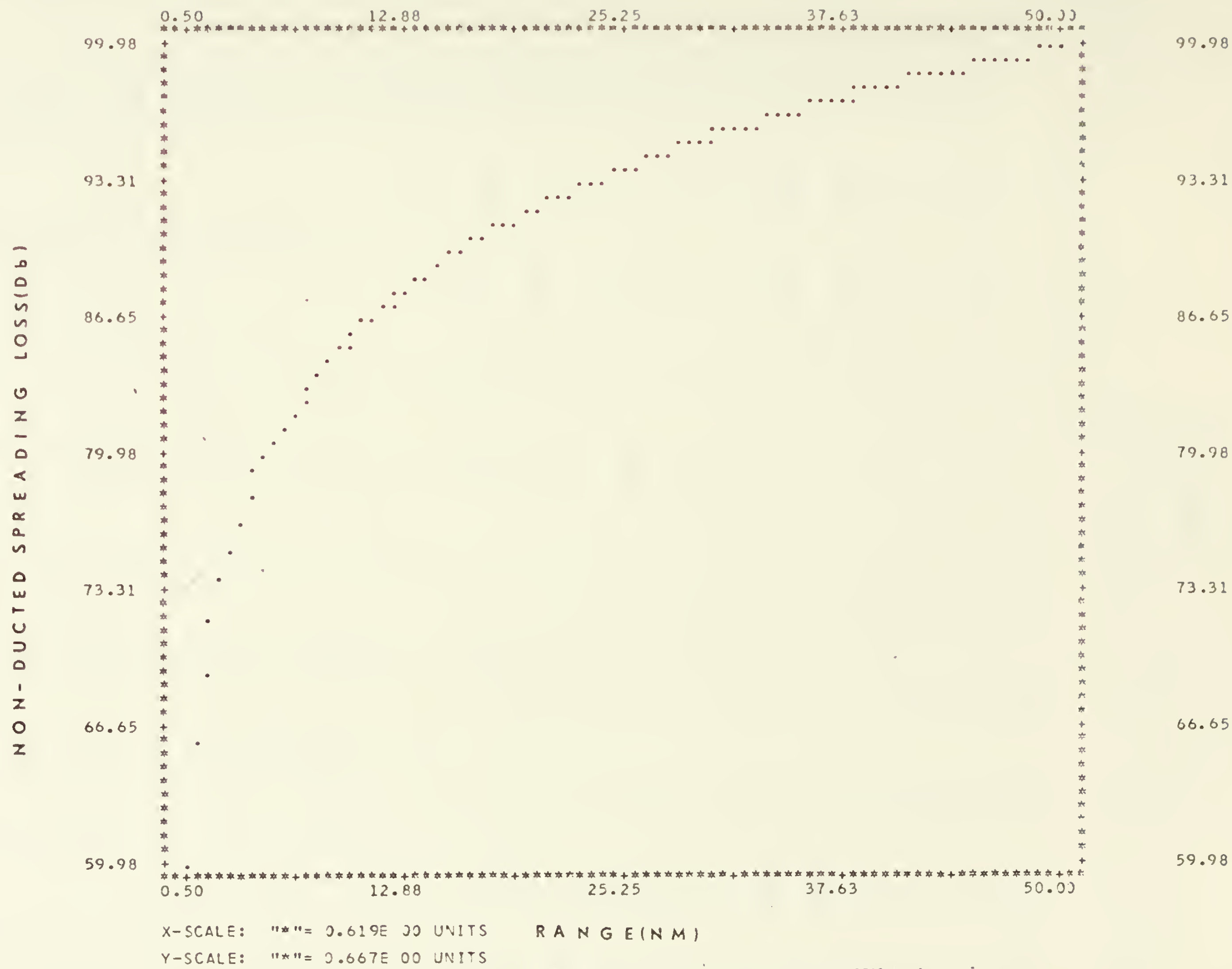


Figure A-2. Non-ducted (spherical) spreading as a function of range.

Table A-4. PROPAGATION LOSS IN DB/NM FOR 100 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	****	****	****	****	****	****	****	****	****	****
150.0	****	****	****	****	****	****	****	****	****	****
175.0	****	****	****	****	****	****	****	****	****	****
200.0	****	****	****	****	****	****	****	****	****	****
225.0	****	****	****	****	****	****	****	****	****	****
250.0	****	****	****	****	****	****	****	****	****	****
275.0	****	****	****	****	****	****	****	****	****	****
300.0	****	****	****	****	****	****	****	****	****	****
325.0	****	****	****	****	****	****	****	****	****	****
350.0	****	****	****	****	****	****	****	****	****	****
375.0	****	****	****	****	****	****	****	****	****	****
400.0	2.5	1.9	1.7	1.6	1.4	1.4	1.3	1.3	1.2	1.2
425.0	2.1	1.6	1.4	1.3	1.2	1.2	1.1	1.1	1.0	1.0
450.0	1.8	1.4	1.2	1.1	1.1	1.0	1.0	0.9	0.9	0.9
475.0	1.5	1.2	1.1	1.0	0.9	0.9	0.8	0.8	0.8	0.7
500.0	1.3	1.0	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7
525.0	1.2	0.9	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6
550.0	1.0	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5
575.0	0.9	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
600.0	0.8	0.7	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4
625.0	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
650.0	0.7	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4
675.0	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
700.0	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
725.0	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
750.0	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table A-5. PROPAGATION LOSS IN DB/NM FOR 200 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	****	****	****	****	****	****	****	****	****	****
150.0	****	****	****	****	****	****	****	****	****	****
175.0	****	****	****	****	****	****	****	****	****	****
200.0	****	****	****	****	****	****	****	****	****	****
225.0	****	****	****	****	****	****	****	****	****	****
250.0	3.3	2.6	2.3	2.1	1.9	1.8	1.8	1.7	1.6	1.6
275.0	2.5	2.0	1.8	1.6	1.5	1.4	1.4	1.3	1.3	1.2
300.0	2.0	1.6	1.4	1.3	1.2	1.2	1.1	1.1	1.0	1.0
325.0	1.6	1.3	1.1	1.1	1.0	0.9	0.9	0.9	0.9	0.8
350.0	1.3	1.1	1.0	0.9	0.8	0.8	0.8	0.7	0.7	0.7
375.0	1.1	0.9	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6
400.0	0.9	0.8	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.5
425.0	0.8	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
450.0	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4
475.0	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
500.0	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
525.0	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
550.0	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
575.0	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
600.0	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
625.0	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
650.0	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
675.0	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
700.0	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
725.0	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
750.0	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table A-6. PROPAGATION LOSS IN DB/NM FOR 300 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	****	****	****	****	****	****	****	****	****	****
150.0	****	****	****	****	****	****	****	****	****	****
175.0	****	****	****	****	****	****	****	****	****	****
200.0	3.4	2.7	2.4	2.2	2.0	1.9	1.9	1.8	1.7	1.7
225.0	2.4	2.0	1.7	1.6	1.5	1.4	1.4	1.3	1.3	1.3
250.0	1.9	1.5	1.3	1.2	1.2	1.1	1.1	1.1	1.0	1.0
275.0	1.5	1.2	1.1	1.0	1.0	0.9	0.9	0.9	0.8	0.8
300.0	1.2	1.0	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7
325.0	1.0	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6
350.0	0.8	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5
375.0	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
400.0	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4
425.0	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4
450.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
475.0	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
500.0	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
525.0	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
550.0	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
575.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
600.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
625.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
650.0	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
675.0	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
700.0	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
725.0	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
750.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table A-7. PROPAGATION LOSS IN DB/NM FOR 400 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	****	****	****	****	****	****	****	****	****	****
150.0	****	****	****	****	****	****	****	****	****	****
175.0	3.2	2.6	2.3	2.1	2.0	1.9	1.8	1.8	1.7	1.7
200.0	2.3	1.9	1.7	1.5	1.5	1.4	1.3	1.3	1.3	1.2
225.0	1.7	1.4	1.3	1.2	1.1	1.1	1.0	1.0	1.0	1.0
250.0	1.3	1.1	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.8
275.0	1.1	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7
300.0	0.9	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6
325.0	0.8	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5
350.0	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
375.0	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4
400.0	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4
425.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
450.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
475.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
500.0	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
525.0	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
550.0	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
575.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
600.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
625.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
650.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
675.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
700.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
725.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2
750.0	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table A-8. PROPAGATION LOSS IN DB/NM FOR 500 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	****	****	****	****	****	****	****	****	****	****
150.0	3.6	2.9	2.6	2.4	2.2	2.1	2.1	2.0	1.9	1.9
175.0	2.4	2.0	1.8	1.7	1.6	1.5	1.5	1.4	1.4	1.4
200.0	1.8	1.5	1.3	1.3	1.2	1.2	1.1	1.1	1.1	1.0
225.0	1.4	1.1	1.1	1.0	1.0	0.9	0.9	0.9	0.9	0.9
250.0	1.1	0.9	0.9	0.8	0.8	0.8	0.8	0.7	0.7	0.7
275.0	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6
300.0	0.8	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
325.0	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
350.0	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
375.0	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4
400.0	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4
425.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
450.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
475.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
500.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
525.0	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
550.0	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
575.0	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
600.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
625.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
650.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
675.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
700.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
725.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
750.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table A-9. PROPAGATION LOSS IN DB/NM FOR 600 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	4.5	3.6	3.2	3.0	2.8	2.7	2.6	2.5	2.4	2.4
150.0	2.8	2.3	2.1	2.0	1.9	1.8	1.7	1.7	1.6	1.6
175.0	2.0	1.7	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2
200.0	1.5	1.3	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0
225.0	1.2	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.8	0.8
250.0	1.0	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7
275.0	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
300.0	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
325.0	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
350.0	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
375.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
400.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4
425.0	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
450.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
475.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
500.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
525.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
550.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
575.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
600.0	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
625.0	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
650.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
675.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
700.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
725.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
750.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table A-10. PROPAGATION LOSS IN DB/NM FOR 700 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	3.7	3.0	2.7	2.5	2.4	2.3	2.2	2.2	2.1	2.1
150.0	2.4	2.0	1.8	1.7	1.6	1.6	1.5	1.5	1.5	1.4
175.0	1.7	1.5	1.4	1.3	1.2	1.2	1.2	1.1	1.1	1.1
200.0	1.3	1.2	1.1	1.0	1.0	1.0	1.0	0.9	0.9	0.9
225.0	1.1	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8
250.0	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7
275.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6
300.0	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
325.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
350.0	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
375.0	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
400.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
425.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
450.0	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
475.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
500.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
525.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
550.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
575.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
600.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
625.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
650.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
675.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
700.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
725.0	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
750.0	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table A-11. PROPAGATION LOSS IN DB/NM FOR 800 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	5.6	4.5	4.0	3.7	3.5	3.3	3.2	3.1	3.0	2.9
125.0	3.2	2.6	2.4	2.2	2.1	2.1	2.0	1.9	1.9	1.9
150.0	2.1	1.8	1.7	1.6	1.5	1.5	1.4	1.4	1.4	1.3
175.0	1.6	1.4	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.1
200.0	1.2	1.1	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9
225.0	1.0	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8
250.0	0.9	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7
275.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
300.0	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
325.0	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
350.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
375.0	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
400.0	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
425.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
450.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
475.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
500.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
525.0	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
550.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
575.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
600.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
625.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
650.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
675.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
700.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
725.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
750.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table A-12. PROPAGATION LOSS IN DB/NM FOR 900 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	4.8	3.9	3.5	3.3	3.1	3.0	2.9	2.8	2.7	2.6
125.0	2.8	2.4	2.2	2.1	2.0	1.9	1.8	1.8	1.8	1.7
150.0	1.9	1.7	1.6	1.5	1.4	1.4	1.4	1.3	1.3	1.3
175.0	1.5	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1
200.0	1.2	1.1	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9
225.0	1.0	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8
250.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7
275.0	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
300.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
325.0	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
350.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
375.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
400.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
425.0	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
450.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
475.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
500.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
525.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
550.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
575.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
600.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
625.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4
650.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
675.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
700.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
725.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
750.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table A-13. PROPAGATION LOSS IN DB/NM FOR 1000 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	4.2	3.5	3.2	3.0	2.8	2.7	2.6	2.6	2.5	2.4
125.0	2.6	2.2	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.7
150.0	1.8	1.6	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3
175.0	1.4	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1
200.0	1.2	1.1	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.9
225.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8
250.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
275.0	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7
300.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
325.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
350.0	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
375.0	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
400.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
425.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
450.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
475.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
500.0	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
525.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
550.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
575.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
600.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
625.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
650.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
675.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
700.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
725.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
750.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table A-14. PROPAGATION LOSS IN DB/NM FOR 1100 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	3.8	3.2	2.9	2.7	2.6	2.5	2.4	2.4	2.3	2.3
125.0	2.4	2.1	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.6
150.0	1.7	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3
175.0	1.4	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1
200.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
225.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
250.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
275.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
300.0	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
325.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
350.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
375.0	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
400.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
425.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
450.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
475.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
500.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
525.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
550.0	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
575.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
600.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
625.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
650.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
675.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
700.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
725.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
750.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table A-15. PROPAGATION LOSS IN DB/NM FOR 1200 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	6.9	5.6	5.0	4.7	4.4	4.2	4.1	4.0	3.9	3.8
100.0	3.5	3.0	2.7	2.6	2.5	2.4	2.3	2.3	2.2	2.2
125.0	2.2	2.0	1.8	1.8	1.7	1.7	1.6	1.6	1.6	1.6
150.0	1.7	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3
175.0	1.3	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1
200.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
225.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
250.0	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8
275.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
300.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
325.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
350.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
375.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
400.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
425.0	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
450.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
475.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
500.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
525.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
550.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
575.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
600.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
625.0	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
650.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
675.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
700.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
725.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
750.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table A-16. PROPAGATION LOSS IN DB/NM FOR 1300 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	6.3	5.1	4.6	4.3	4.1	3.9	3.8	3.7	3.6	3.5
100.0	3.3	2.8	2.6	2.4	2.3	2.3	2.2	2.2	2.1	2.1
125.0	2.1	1.9	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.5
150.0	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3
175.0	1.3	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1
200.0	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
225.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9
250.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
275.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
300.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
325.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
350.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
375.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
400.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
425.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
450.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
475.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
500.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
525.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
550.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6
575.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
600.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
625.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
650.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
675.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
700.0	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
725.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
750.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table A-17. PROPAGATION LOSS IN DB/NM FOR 1400 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	5.8	4.8	4.3	4.0	3.8	3.7	3.6	3.5	3.4	3.3
100.0	3.1	2.7	2.5	2.3	2.3	2.2	2.2	2.1	2.1	2.0
125.0	2.1	1.8	1.8	1.7	1.6	1.6	1.6	1.6	1.6	1.5
150.0	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3
175.0	1.3	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1
200.0	1.2	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
225.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
250.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
275.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
300.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
325.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
350.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
375.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
400.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
425.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
450.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
475.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
500.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
525.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6
550.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
575.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
600.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
625.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
650.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6
675.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
700.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6
725.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6
750.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Table A-18. PROPAGATION LOSS IN DB/NM FOR 1500 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	5.3	4.4	4.0	3.8	3.6	3.5	3.4	3.3	3.2	3.2
100.0	2.9	2.5	2.4	2.3	2.2	2.1	2.1	2.1	2.0	2.0
125.0	2.0	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.5
150.0	1.6	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3
175.0	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
200.0	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
225.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
250.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
275.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
300.0	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8
325.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
350.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
375.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
400.0	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7
425.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
450.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
475.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
500.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
525.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
550.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
575.0	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
600.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
625.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
650.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
675.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
700.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
725.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
750.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Table A-19. PROPAGATION LOSS IN DB/NM FOR 1600 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	5.0	4.2	3.8	3.6	3.5	3.3	3.2	3.2	3.1	3.0
100.0	2.8	2.5	2.3	2.2	2.2	2.1	2.1	2.0	2.0	2.0
125.0	2.0	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.5
150.0	1.6	1.5	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3
175.0	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
200.0	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
225.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
250.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
275.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
300.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
325.0	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8
350.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
375.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
400.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
425.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
450.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
475.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
500.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
525.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
550.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
575.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
600.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
625.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
650.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
675.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
700.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
725.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
750.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Table A-20. PROPAGATION LOSS IN DB/NM FOR 1700 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	4.7	4.0	3.7	3.5	3.3	3.2	3.1	3.1	3.0	3.0
100.0	2.7	2.4	2.3	2.2	2.1	2.1	2.0	2.0	2.0	2.0
125.0	1.9	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6
150.0	1.6	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.3
175.0	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2
200.0	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
225.0	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
250.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
275.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9
300.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
325.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
350.0	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8
375.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
400.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
425.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
450.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
475.0	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7
500.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
525.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
550.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
575.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
600.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
625.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
650.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
675.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
700.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
725.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
750.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Table A-21. PROPAGATION LOSS IN DB/NM FOR 1800 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	4.5	3.8	3.5	3.3	3.2	3.1	3.0	3.0	2.9	2.9
100.0	2.6	2.4	2.2	2.2	2.1	2.1	2.0	2.0	2.0	2.0
125.0	1.9	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6
150.0	1.6	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
175.0	1.4	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2
200.0	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1
225.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
250.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
275.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
300.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
325.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
350.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
375.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8
400.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
425.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
450.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
475.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
500.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
525.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
550.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
575.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
600.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
625.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
650.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
675.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
700.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
725.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
750.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Table A-22. PROPAGATION LOSS IN DB/NM FOR 1900 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	4.3	3.7	3.4	3.2	3.1	3.0	3.0	2.9	2.9	2.8
100.0	2.6	2.3	2.2	2.1	2.1	2.0	2.0	2.0	2.0	2.0
125.0	1.9	1.8	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6
150.0	1.6	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4
175.0	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
200.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
225.0	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
250.0	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
275.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
300.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
325.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
350.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
375.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
400.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
425.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
450.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
475.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
500.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
525.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
550.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
575.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
600.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
625.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
650.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
675.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
700.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
725.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
750.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Table A-23. PROPAGATION LOSS IN DB/NM FOR 2000 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	4.1	3.6	3.3	3.2	3.1	3.0	2.9	2.9	2.8	2.8
100.0	2.5	2.3	2.2	2.1	2.1	2.0	2.0	2.0	2.0	2.0
125.0	1.9	1.8	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6
150.0	1.6	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4
175.0	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
200.0	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
225.0	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
250.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
275.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
300.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
325.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
350.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
375.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
400.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
425.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
450.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
475.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
500.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
525.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
550.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
575.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
600.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
625.0	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
650.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
675.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
700.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
725.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
750.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Table A-24. PROPAGATION LOSS IN DB/NM FOR 2100 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	4.0	3.5	3.2	3.1	3.0	2.9	2.9	2.8	2.8	2.7
100.0	2.5	2.3	2.2	2.1	2.1	2.0	2.0	2.0	2.0	2.0
125.0	1.9	1.8	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6
150.0	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4
175.0	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3
200.0	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
225.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
250.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
275.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
300.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
325.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
350.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
375.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
400.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
425.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
450.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
475.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
500.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
525.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
550.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
575.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
600.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
625.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
650.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
675.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
700.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
725.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
750.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Table A-25. PROPAGATION LOSS IN DB/NM FOR 2200 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	9.1	7.5	6.8	6.3	6.0	5.8	5.6	5.4	5.3	5.2
75.0	3.9	3.4	3.2	3.0	2.9	2.9	2.8	2.8	2.7	2.7
100.0	2.5	2.3	2.2	2.1	2.1	2.0	2.0	2.0	2.0	2.0
125.0	1.9	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6
150.0	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
175.0	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3
200.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
225.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
250.0	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
275.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
300.0	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0
325.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
350.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
375.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
400.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
425.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
450.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
475.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
500.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
525.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
550.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
575.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
600.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
625.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
650.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
675.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
700.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
725.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
750.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Table A-26. PROPAGATION LOSS IN DB/NM FOR 2300 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	8.6	7.2	6.5	6.1	5.8	5.6	5.4	5.3	5.1	5.0
75.0	3.8	3.3	3.1	3.0	2.9	2.8	2.8	2.8	2.7	2.7
100.0	2.4	2.3	2.2	2.1	2.1	2.1	2.0	2.0	2.0	2.0
125.0	1.9	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7
150.0	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
175.0	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
200.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
225.0	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
250.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
275.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
300.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
325.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
350.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
375.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
400.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
425.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
450.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
475.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
500.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
525.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
550.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
575.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
600.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
625.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
650.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
675.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
700.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
725.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
750.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Table A-27. PROPAGATION LOSS IN DB/NM FOR 2400 HZ

***: NON-DUCTED CASE

SEA STATE : LESS THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	8.2	6.9	6.2	5.9	5.6	5.4	5.2	5.1	5.0	4.9
75.0	3.7	3.3	3.1	3.0	2.9	2.8	2.8	2.7	2.7	2.7
100.0	2.4	2.3	2.2	2.1	2.1	2.1	2.0	2.0	2.0	2.0
125.0	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7
150.0	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5
175.0	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
200.0	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
225.0	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2
250.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
275.0	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
300.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
325.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
350.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
375.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
400.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
425.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
450.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
475.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
500.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
525.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
550.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
575.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
600.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
625.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
650.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
675.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
700.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
725.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
750.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Table A-28. PROPAGATION LOSS IN DB/NM FOR 100 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	****	****	****	****	****	****	****	****	****	****
150.0	****	****	****	****	****	****	****	****	****	****
175.0	****	****	****	****	****	****	****	****	****	****
200.0	****	****	****	****	****	****	****	****	****	****
225.0	****	****	****	****	****	****	****	****	****	****
250.0	****	****	****	****	****	****	****	****	****	****
275.0	****	****	****	****	****	****	****	****	****	****
300.0	****	****	****	****	****	****	****	****	****	****
325.0	****	****	****	****	****	****	****	****	****	****
350.0	****	****	****	****	****	****	****	****	****	****
375.0	****	****	****	****	****	****	****	****	****	****
400.0	2.6	2.1	1.8	1.7	1.6	1.5	1.4	1.4	1.4	1.3
425.0	2.2	1.8	1.6	1.5	1.4	1.3	1.2	1.2	1.2	1.1
450.0	1.9	1.5	1.4	1.3	1.2	1.1	1.1	1.0	1.0	1.0
475.0	1.7	1.3	1.2	1.1	1.0	1.0	1.0	0.9	0.9	0.9
500.0	1.5	1.2	1.1	1.0	0.9	0.9	0.9	0.8	0.8	0.8
525.0	1.3	1.0	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.7
550.0	1.1	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.6
575.0	1.0	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6
600.0	0.9	0.8	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.5
625.0	0.8	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5
650.0	0.8	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
675.0	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4
700.0	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
725.0	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4
750.0	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table A-29. PROPAGATION LOSS IN DB/NM FOR 200 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	****	****	****	****	****	****	****	****	****	****
150.0	****	****	****	****	****	****	****	****	****	****
175.0	****	****	****	****	****	****	****	****	****	****
200.0	****	****	****	****	****	****	****	****	****	****
225.0	****	****	****	****	****	****	****	****	****	****
250.0	3.5	2.8	2.5	2.3	2.2	2.1	2.0	1.9	1.9	1.8
275.0	2.8	2.2	2.0	1.9	1.8	1.7	1.6	1.6	1.5	1.5
300.0	2.2	1.8	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.2
325.0	1.8	1.5	1.4	1.3	1.2	1.2	1.1	1.1	1.1	1.1
350.0	1.5	1.3	1.2	1.1	1.0	1.0	1.0	1.0	0.9	0.9
375.0	1.3	1.1	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.8
400.0	1.1	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.7	0.7
425.0	1.0	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7
450.0	0.9	0.8	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
475.0	0.8	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
500.0	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5
525.0	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
550.0	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
575.0	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4
600.0	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
625.0	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4
650.0	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
675.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
700.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
725.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
750.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3

Table A-30. PROPAGATION LOSS IN DB/NM FOR 300 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	****	****	****	****	****	****	****	****	****	****
150.0	****	****	****	****	****	****	****	****	****	****
175.0	****	****	****	****	****	****	****	****	****	****
200.0	3.7	3.0	2.7	2.5	2.4	2.3	2.2	2.1	2.1	2.0
225.0	2.8	2.3	2.1	1.9	1.8	1.8	1.7	1.7	1.6	1.6
250.0	2.2	1.8	1.7	1.6	1.5	1.4	1.4	1.4	1.3	1.3
275.0	1.8	1.5	1.4	1.3	1.2	1.2	1.2	1.2	1.1	1.1
300.0	1.5	1.3	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0
325.0	1.3	1.1	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9
350.0	1.1	1.0	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8
375.0	1.0	0.9	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7
400.0	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7
425.0	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
450.0	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
475.0	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
500.0	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5
525.0	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
550.0	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
575.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
600.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
625.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4
650.0	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
675.0	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
700.0	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
725.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
750.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table A-31. PROPAGATION LOSS IN DB/NM FOR 400 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	****	****	****	****	****	****	****	****	****	****
150.0	****	****	****	****	****	****	****	****	****	****
175.0	3.6	3.0	2.7	2.5	2.4	2.3	2.3	2.2	2.1	2.1
200.0	2.7	2.3	2.1	1.9	1.9	1.8	1.7	1.7	1.7	1.6
225.0	2.1	1.8	1.6	1.6	1.5	1.5	1.4	1.4	1.4	1.4
250.0	1.7	1.5	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2
275.0	1.4	1.3	1.2	1.1	1.1	1.1	1.1	1.0	1.0	1.0
300.0	1.2	1.1	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9
325.0	1.1	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.8
350.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
375.0	0.9	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7
400.0	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
425.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
450.0	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
475.0	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
500.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
525.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
550.0	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5
575.0	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
600.0	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
625.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
650.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
675.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
700.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
725.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
750.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table A-32. PROPAGATION LOSS IN DB/NM FOR 500 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	****	****	****	****	****	****	****	****	****	****
150.0	4.1	3.4	3.1	2.9	2.8	2.7	2.6	2.5	2.5	2.4
175.0	2.9	2.5	2.3	2.1	2.1	2.0	1.9	1.9	1.9	1.8
200.0	2.2	1.9	1.8	1.7	1.6	1.6	1.6	1.5	1.5	1.5
225.0	1.8	1.6	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3
250.0	1.5	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1	1.1
275.0	1.3	1.2	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0
300.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9
325.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
350.0	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8
375.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
400.0	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7
425.0	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
450.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
475.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
500.0	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
525.0	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
550.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
575.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
600.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
625.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
650.0	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5
675.0	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
700.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
725.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
750.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table A-33. PROPAGATION LOSS IN DB/NM FOR 600 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	5.2	4.3	3.9	3.6	3.4	3.3	3.2	3.1	3.1	3.0
150.0	3.4	2.9	2.7	2.5	2.4	2.4	2.3	2.2	2.2	2.2
175.0	2.5	2.2	2.0	1.9	1.9	1.8	1.8	1.8	1.7	1.7
200.0	2.0	1.8	1.7	1.6	1.6	1.5	1.5	1.5	1.5	1.4
225.0	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3
250.0	1.4	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1
275.0	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0
300.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
325.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9
350.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
375.0	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8
400.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
425.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
450.0	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7
475.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
500.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
525.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
550.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
575.0	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
600.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
625.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
650.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
675.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
700.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
725.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
750.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Table A-34. PROPAGATION LOSS IN DB/NM FOR 700 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	****	****	****	****	****	****	****	****	****	****
125.0	4.4	3.7	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.7
150.0	3.0	2.6	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.1
175.0	2.3	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.7	1.7
200.0	1.9	1.7	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.4
225.0	1.6	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3
250.0	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2
275.0	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1
300.0	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
325.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
350.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9
375.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
400.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
425.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
450.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
475.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
500.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
525.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
550.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
575.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
600.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
625.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
650.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
675.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6
700.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
725.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
750.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Table A-35. PROPAGATION LOSS IN DB/NM FOR 800 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	6.4	5.3	4.8	4.5	4.3	4.1	4.0	3.9	3.8	3.7
125.0	3.9	3.4	3.1	3.0	2.9	2.8	2.7	2.7	2.6	2.6
150.0	2.8	2.5	2.3	2.2	2.2	2.1	2.1	2.1	2.0	2.0
175.0	2.2	2.0	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.7
200.0	1.8	1.7	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5
225.0	1.6	1.5	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.3
250.0	1.4	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2
275.0	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1
300.0	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
325.0	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0
350.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
375.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
400.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
425.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
450.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
475.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
500.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
525.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
550.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
575.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
600.0	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7
625.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
650.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
675.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
700.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
725.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
750.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Table A-36. PROPAGATION LOSS IN DB/NM FOR 900 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	5.6	4.8	4.4	4.1	4.0	3.8	3.7	3.6	3.6	3.5
125.0	3.6	3.1	2.9	2.8	2.7	2.7	2.6	2.6	2.5	2.5
150.0	2.6	2.4	2.3	2.2	2.1	2.1	2.1	2.0	2.0	2.0
175.0	2.1	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.7
200.0	1.8	1.7	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5
225.0	1.6	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4
250.0	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
275.0	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2
300.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1
325.0	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
350.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
375.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
400.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
425.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
450.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
475.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
500.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
525.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
550.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
575.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
600.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
625.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
650.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
675.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
700.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
725.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
750.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Table A-37. PROPAGATION LOSS IN DB/NM FOR 1000 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	5.1	4.4	4.1	3.9	3.7	3.6	3.5	3.5	3.4	3.3
125.0	3.4	3.0	2.8	2.7	2.7	2.6	2.6	2.5	2.5	2.5
150.0	2.5	2.3	2.2	2.2	2.1	2.1	2.1	2.0	2.0	2.0
175.0	2.1	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8
200.0	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6
225.0	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.4
250.0	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
275.0	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
300.0	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
325.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
350.0	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
375.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
400.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0
425.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
450.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
475.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
500.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
525.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
550.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
575.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
600.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
625.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
650.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
675.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
700.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
725.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
750.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Table A-38. PROPAGATION LOSS IN DB/NM FOR 1100 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	****	****	****	****	****	****	****	****	****	****
100.0	4.8	4.1	3.9	3.7	3.6	3.5	3.4	3.3	3.3	3.2
125.0	3.2	2.9	2.8	2.7	2.6	2.6	2.5	2.5	2.5	2.4
150.0	2.5	2.3	2.2	2.2	2.1	2.1	2.1	2.1	2.0	2.0
175.0	2.1	2.0	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8
200.0	1.8	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6
225.0	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5
250.0	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
275.0	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3
300.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
325.0	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
350.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
375.0	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
400.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
425.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
450.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
475.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
500.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
525.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
550.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
575.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
600.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
625.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
650.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
675.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
700.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
725.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
750.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Table A-39. PROPAGATION LOSS IN DB/NM FOR 1200 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	8.1	6.8	6.2	5.8	5.6	5.4	5.2	5.1	5.0	4.9
100.0	4.5	3.9	3.7	3.6	3.4	3.4	3.3	3.2	3.2	3.2
125.0	3.1	2.8	2.7	2.6	2.6	2.5	2.5	2.5	2.5	2.4
150.0	2.5	2.3	2.2	2.2	2.1	2.1	2.1	2.1	2.1	2.1
175.0	2.1	2.0	1.9	1.9	1.9	1.9	1.9	1.8	1.8	1.8
200.0	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
225.0	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
250.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
275.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
300.0	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
325.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
350.0	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
375.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
400.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1
425.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
450.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
475.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
500.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
525.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
550.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
575.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
600.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
625.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
650.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
675.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
700.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
725.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
750.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Table A-40. PROPAGATION LOSS IN DB/NM FOR 1300 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	7.5	6.3	5.8	5.5	5.3	5.1	5.0	4.9	4.8	4.7
100.0	4.3	3.8	3.6	3.5	3.4	3.3	3.2	3.2	3.2	3.1
125.0	3.1	2.8	2.7	2.6	2.6	2.6	2.5	2.5	2.5	2.5
150.0	2.5	2.3	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1
175.0	2.1	2.0	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9
200.0	1.9	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7
225.0	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
250.0	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
275.0	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4
300.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
325.0	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
350.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
375.0	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
400.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
425.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
450.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
475.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
500.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
525.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
550.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
575.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
600.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
625.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
650.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
675.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
700.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
725.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
750.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Table A-41. PROPAGATION LOSS IN DB/NM FOR 1400 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	7.0	6.0	5.5	5.3	5.1	4.9	4.8	4.7	4.6	4.6
100.0	4.1	3.7	3.5	3.4	3.3	3.3	3.2	3.2	3.1	3.1
125.0	3.0	2.8	2.7	2.6	2.6	2.6	2.5	2.5	2.5	2.5
150.0	2.5	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.1
175.0	2.1	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.9	1.9
200.0	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
225.0	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
250.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
275.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
300.0	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
325.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
350.0	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
375.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
400.0	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2
425.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
450.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
475.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
500.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
525.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
550.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
575.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
600.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
625.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
650.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
675.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
700.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
725.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
750.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table A-42. PROPAGATION LOSS IN DB/NM FOR 1500 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	6.6	5.7	5.3	5.1	4.9	4.8	4.7	4.6	4.5	4.4
100.0	4.0	3.6	3.5	3.4	3.3	3.2	3.2	3.2	3.1	3.1
125.0	3.0	2.8	2.7	2.7	2.6	2.6	2.6	2.6	2.5	2.5
150.0	2.5	2.4	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2
175.0	2.2	2.1	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.0
200.0	1.9	1.9	1.9	1.9	1.9	1.8	1.8	1.8	1.8	1.8
225.0	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
250.0	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
275.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.5	1.5
300.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
325.0	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
350.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
375.0	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
400.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
425.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
450.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
475.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
500.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
525.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1
550.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
575.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
600.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
625.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
650.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0
675.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
700.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
725.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
750.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table A-43. PROPAGATION LOSS IN DB/NM FOR 1600 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	6.3	5.5	5.1	4.9	4.8	4.7	4.6	4.5	4.4	4.4
100.0	3.9	3.6	3.5	3.4	3.3	3.2	3.2	3.2	3.1	3.1
125.0	3.0	2.8	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6
150.0	2.5	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.2
175.0	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0
200.0	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
225.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
250.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
275.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
300.0	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
325.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
350.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
375.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
400.0	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
425.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
450.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
475.0	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
500.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
525.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
550.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
575.0	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
600.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
625.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
650.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
675.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
700.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
725.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
750.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table A-44. PROPAGATION LOSS IN DB/NM FOR 1700 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	6.1	5.3	5.0	4.8	4.7	4.6	4.5	4.4	4.4	4.3
100.0	3.9	3.6	3.4	3.4	3.3	3.2	3.2	3.2	3.2	3.1
125.0	3.0	2.8	2.8	2.7	2.7	2.7	2.6	2.6	2.6	2.6
150.0	2.5	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3
175.0	2.2	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
200.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.9	1.9	1.9
225.0	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
250.0	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
275.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6
300.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
325.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
350.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
375.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
400.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
425.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
450.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
475.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
500.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
525.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
550.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
575.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
600.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
625.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
650.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
675.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
700.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
725.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
750.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

Table A-45. PROPAGATION LOSS IN DB/NM FOR 1800 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	5.9	5.2	4.9	4.7	4.6	4.5	4.4	4.4	4.3	4.3
100.0	3.8	3.6	3.4	3.4	3.3	3.3	3.2	3.2	3.2	3.2
125.0	3.0	2.9	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.6
150.0	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3
175.0	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.1	2.1	2.1
200.0	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
225.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
250.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
275.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
300.0	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
325.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
350.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
375.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
400.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
425.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
450.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
475.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
500.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
525.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
550.0	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2
575.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
600.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
625.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
650.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
675.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
700.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
725.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
750.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

Table A-46.. PROPAGATION LOSS IN DB/NM FOR 1900 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	5.7	5.1	4.8	4.7	4.6	4.5	4.4	4.3	4.3	4.2
100.0	3.8	3.6	3.4	3.4	3.3	3.3	3.3	3.2	3.2	3.2
125.0	3.0	2.9	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7
150.0	2.6	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4
175.0	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
200.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0
225.0	2.0	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
250.0	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
275.0	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7
300.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
325.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
350.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
375.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
400.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
425.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
450.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
475.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
500.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
525.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
550.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
575.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
600.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
625.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
650.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
675.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
700.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
725.0	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1
750.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

Table A-47. PROPAGATION LOSS IN DB/NM FOR 2000 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	5.6	5.0	4.8	4.6	4.5	4.4	4.4	4.3	4.3	4.2
100.0	3.8	3.6	3.5	3.4	3.4	3.3	3.3	3.3	3.2	3.2
125.0	3.0	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.7
150.0	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.4
175.0	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2
200.0	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
225.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
250.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
275.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
300.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
325.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
350.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
375.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
400.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
425.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
450.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
475.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
500.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
525.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
550.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
575.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
600.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
625.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
650.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
675.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
700.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
725.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
750.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

Table A-48. PROPAGATION LOSS IN DB/NM FOR 2100 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	****	****	****	****	****	****	****	****	****	****
75.0	5.5	5.0	4.7	4.6	4.5	4.4	4.4	4.3	4.3	4.2
100.0	3.8	3.6	3.5	3.4	3.4	3.3	3.3	3.3	3.3	3.3
125.0	3.1	3.0	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8
150.0	2.7	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5
175.0	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
200.0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.1	2.1	2.1
225.0	2.1	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
250.0	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
275.0	1.9	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8
300.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
325.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
350.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
375.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
400.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
425.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
450.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
475.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4
500.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
525.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
550.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
575.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
600.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
625.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
650.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
675.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
700.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
725.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
750.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

Table A-49. PROPAGATION LOSS IN DB/NM FOR 2200 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	11.0	9.4	8.7	8.2	7.9	7.7	7.5	7.3	7.2	7.1
75.0	5.4	4.9	4.7	4.6	4.5	4.4	4.4	4.3	4.3	4.2
100.0	3.8	3.6	3.5	3.5	3.4	3.4	3.4	3.3	3.3	3.3
125.0	3.1	3.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.8
150.0	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
175.0	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3
200.0	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
225.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
250.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
275.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
300.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
325.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
350.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
375.0	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
400.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
425.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
450.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
475.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
500.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
525.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
550.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
575.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
600.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
625.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
650.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
675.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
700.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
725.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
750.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

Table A-50. PROPAGATION LOSS IN DB/NM FOR 2300 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	10.6	9.1	8.4	8.0	7.7	7.5	7.3	7.2	7.1	7.0
75.0	5.3	4.9	4.7	4.6	4.5	4.4	4.4	4.3	4.3	4.3
100.0	3.8	3.6	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.4
125.0	3.1	3.0	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.9
150.0	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6
175.0	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
200.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2
225.0	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
250.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
275.0	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
300.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
325.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
350.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
375.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
400.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
425.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
450.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
475.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
500.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
525.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
550.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
575.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
600.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
625.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
650.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
675.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
700.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
725.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
750.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3

Table A-51. PROPAGATION LOSS IN DB/NM FOR 2400 HZ

***: NON-DUCTED CASE

SEA STATE :GREATER THAN 3

LAYER(FT)	BELOW LAYER GRADIENT(DEG.F/100FT.)									
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
50.0	10.2	8.8	8.2	7.8	7.6	7.4	7.2	7.1	7.0	6.9
75.0	5.3	4.9	4.7	4.6	4.5	4.4	4.4	4.3	4.3	4.3
100.0	3.8	3.6	3.6	3.5	3.5	3.5	3.4	3.4	3.4	3.4
125.0	3.2	3.1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.9
150.0	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
175.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
200.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
225.0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
250.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
275.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
300.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
325.0	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
350.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
375.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
400.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
425.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
450.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
475.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
500.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
525.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
550.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
575.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
600.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
625.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
650.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
675.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
700.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
725.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
750.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3

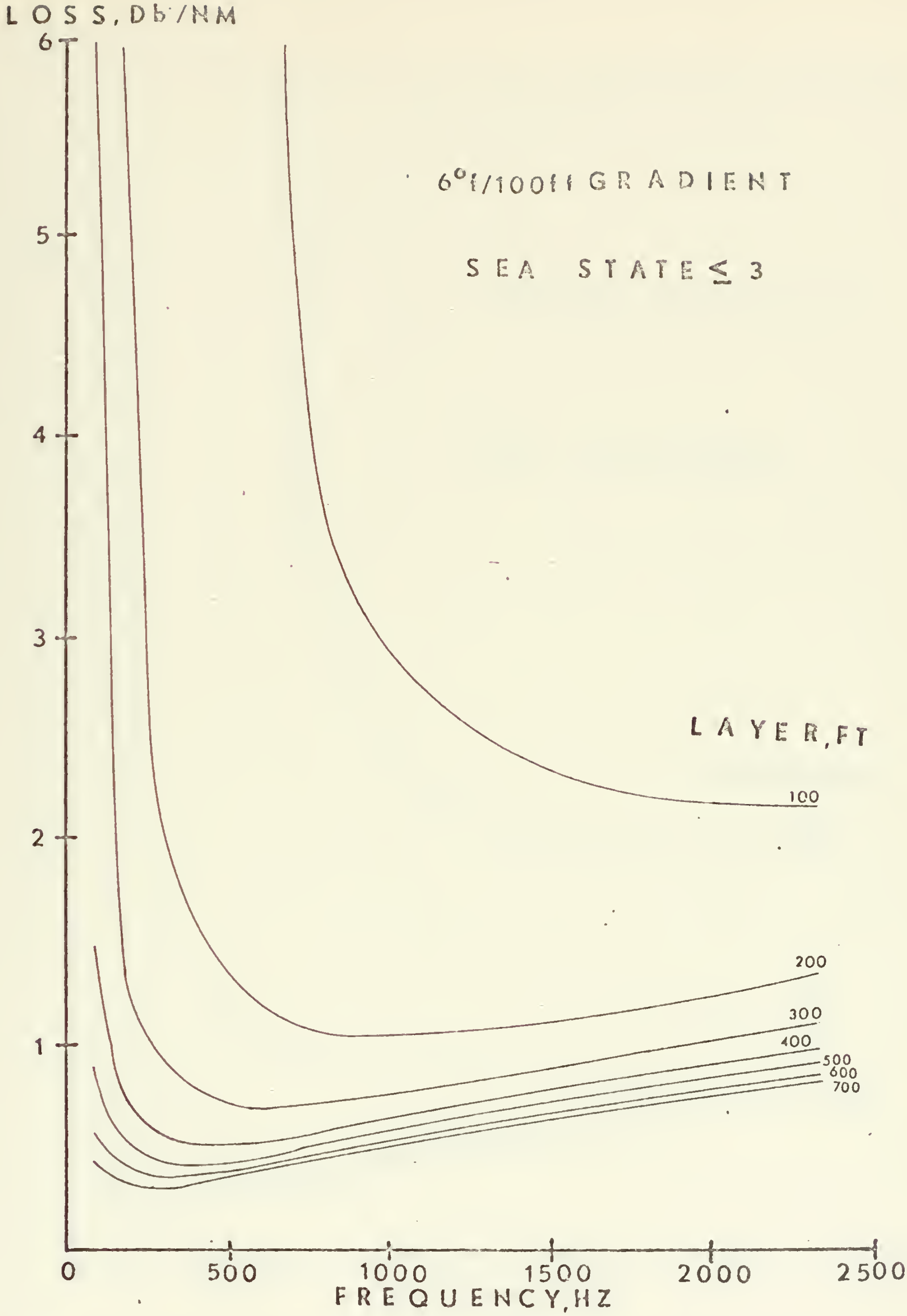


Figure A-3. Propagation loss for low sea state and a below layer gradient of -6°F/100 FT.

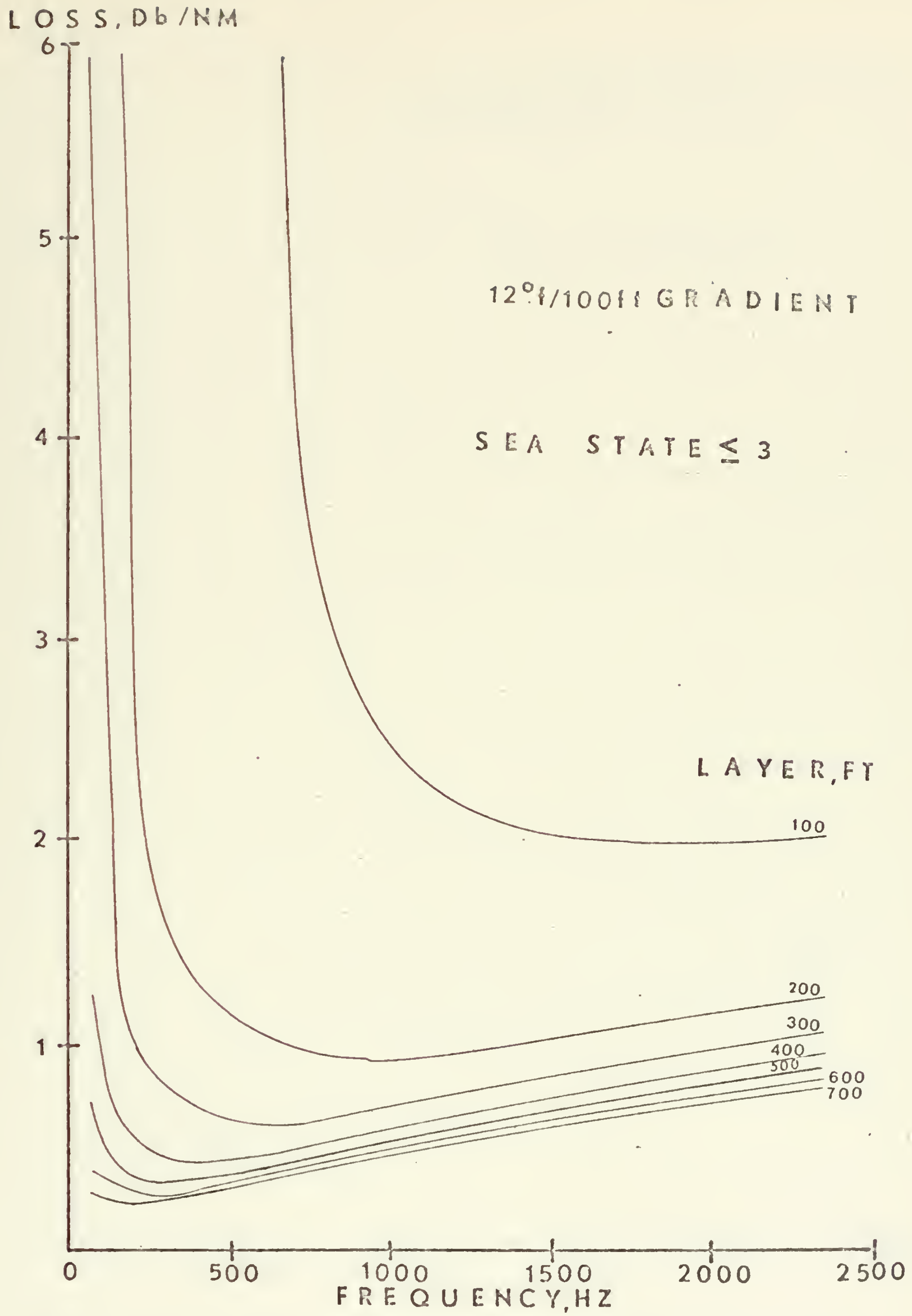


Figure A-4. Propagation loss for low sea state and a below layer gradient of -12°F/100 FT.

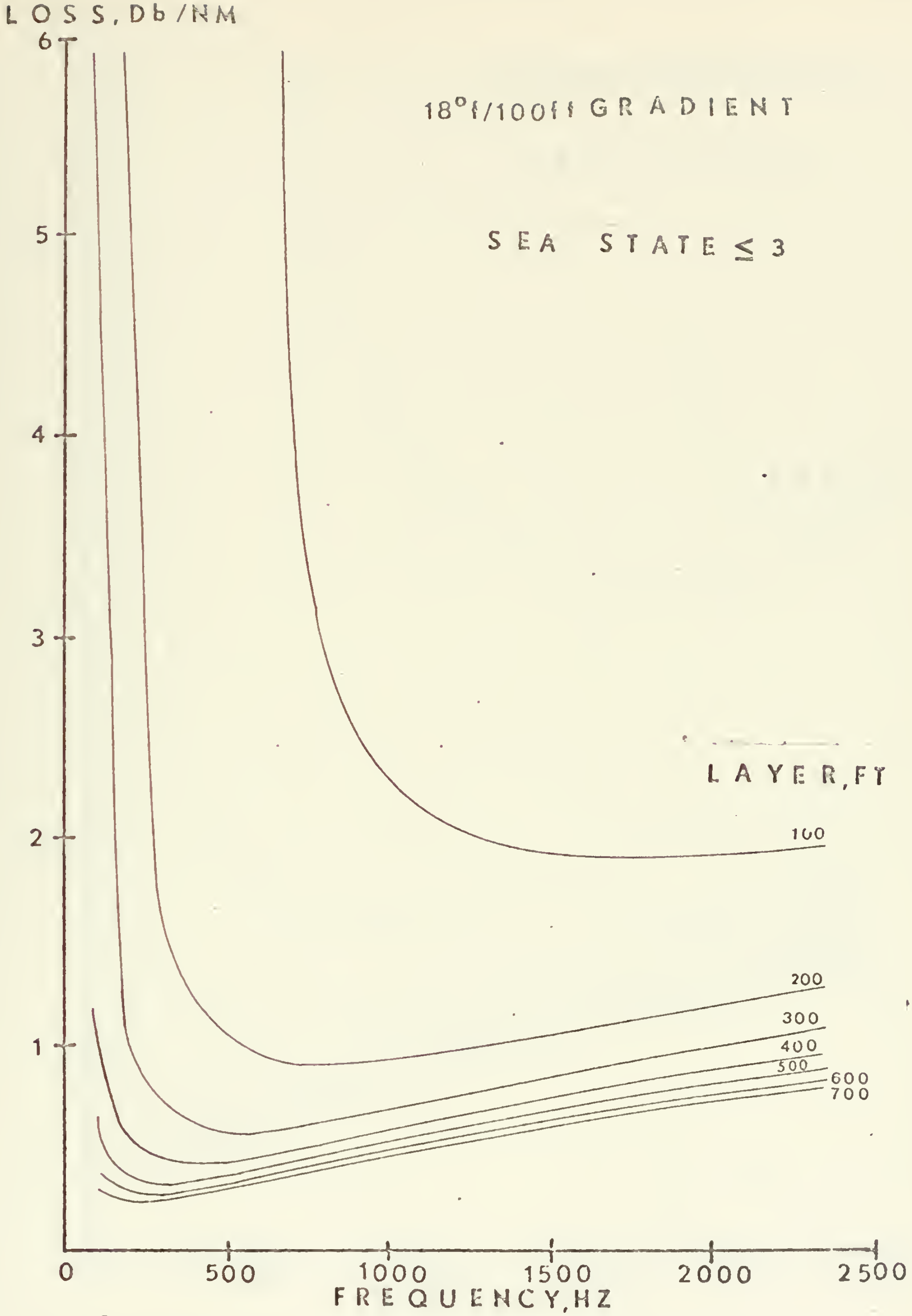


Figure A-5. Propagation loss for low sea state and a below layer gradient of -18°F/100 FT.

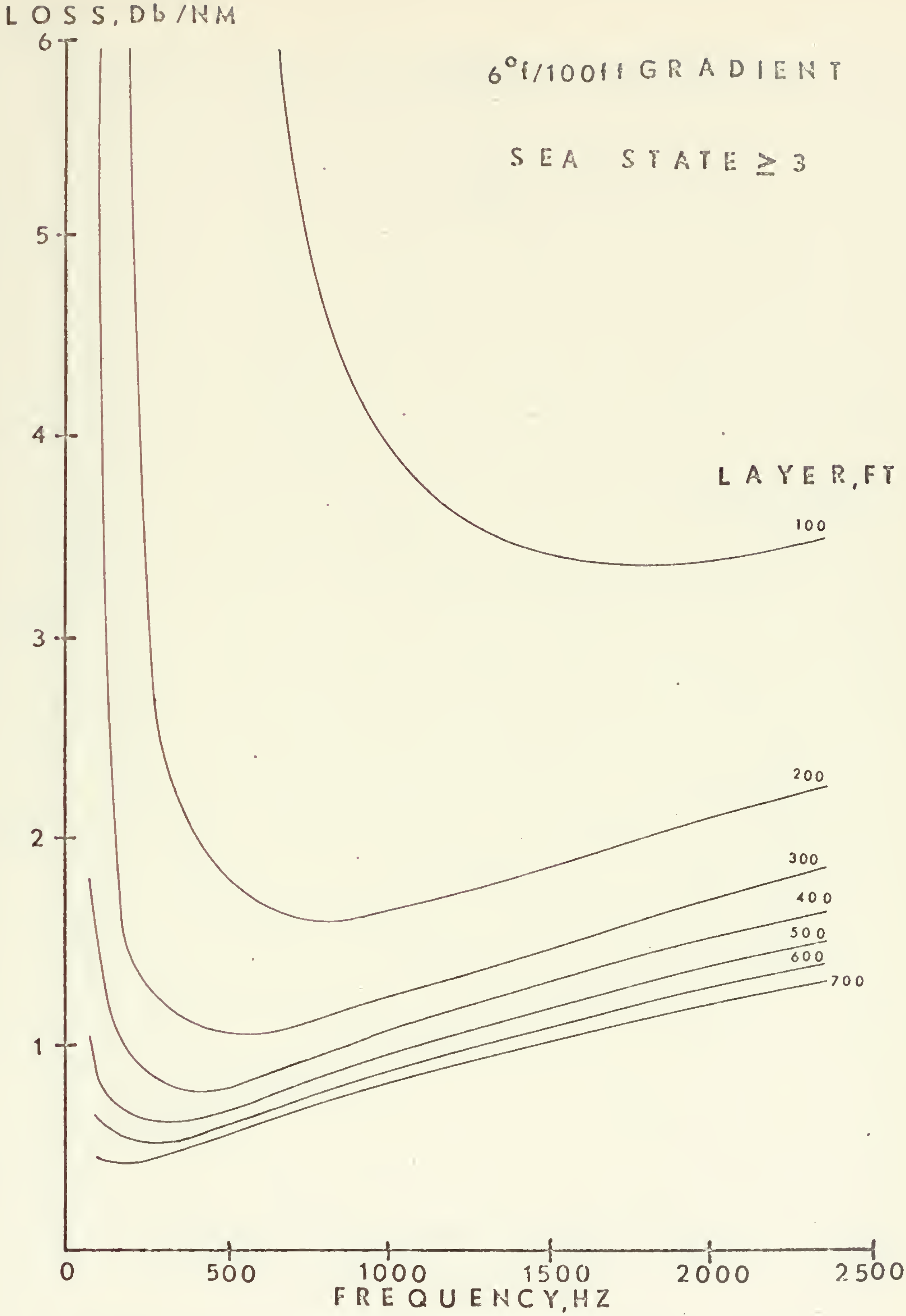


Figure A-6. Propagation loss for high sea state and a below layer gradient of -6°F/100 FT.

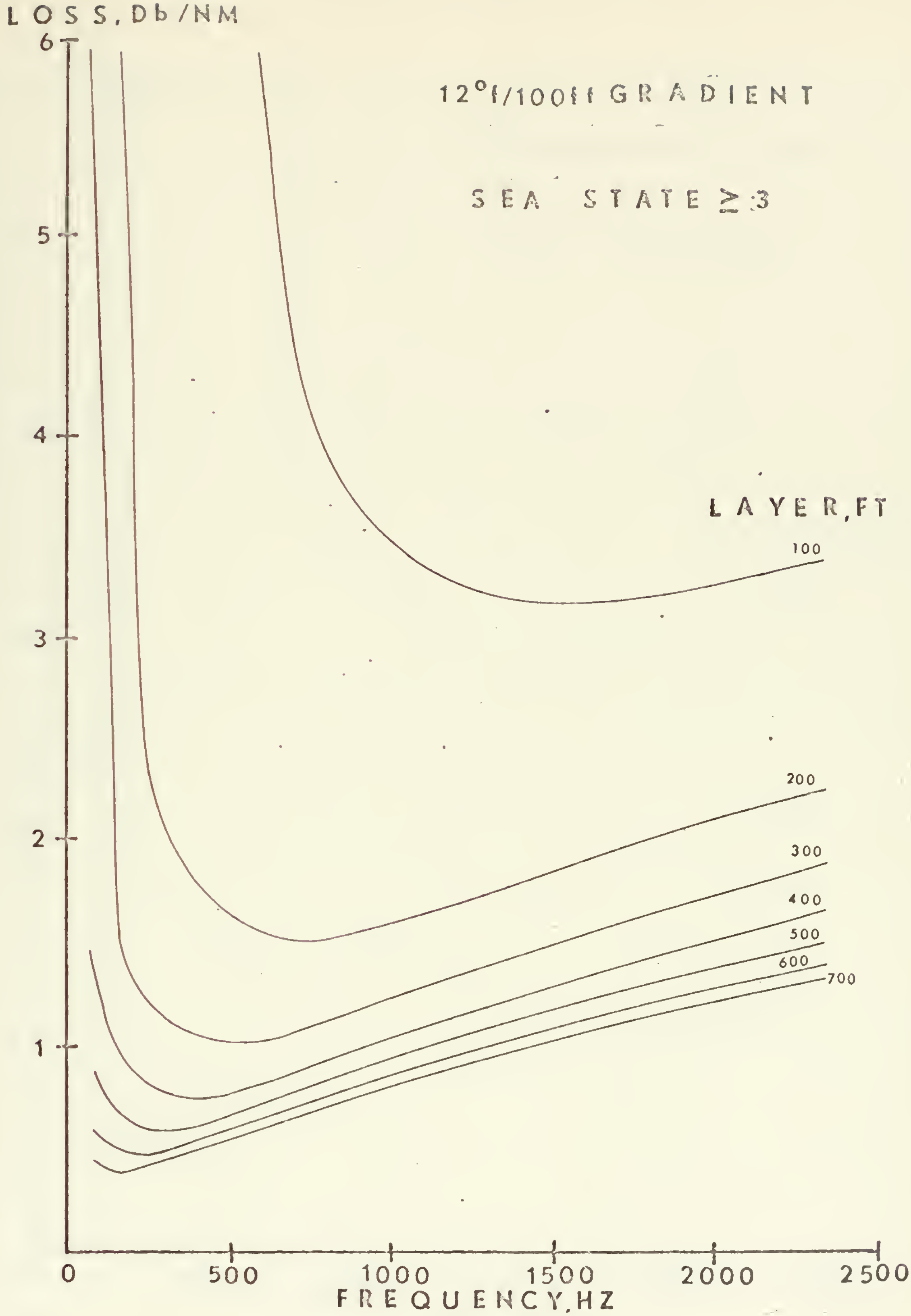


Figure A-7. Propagation loss for high sea state and a below layer gradient of -12°F/100 FT.

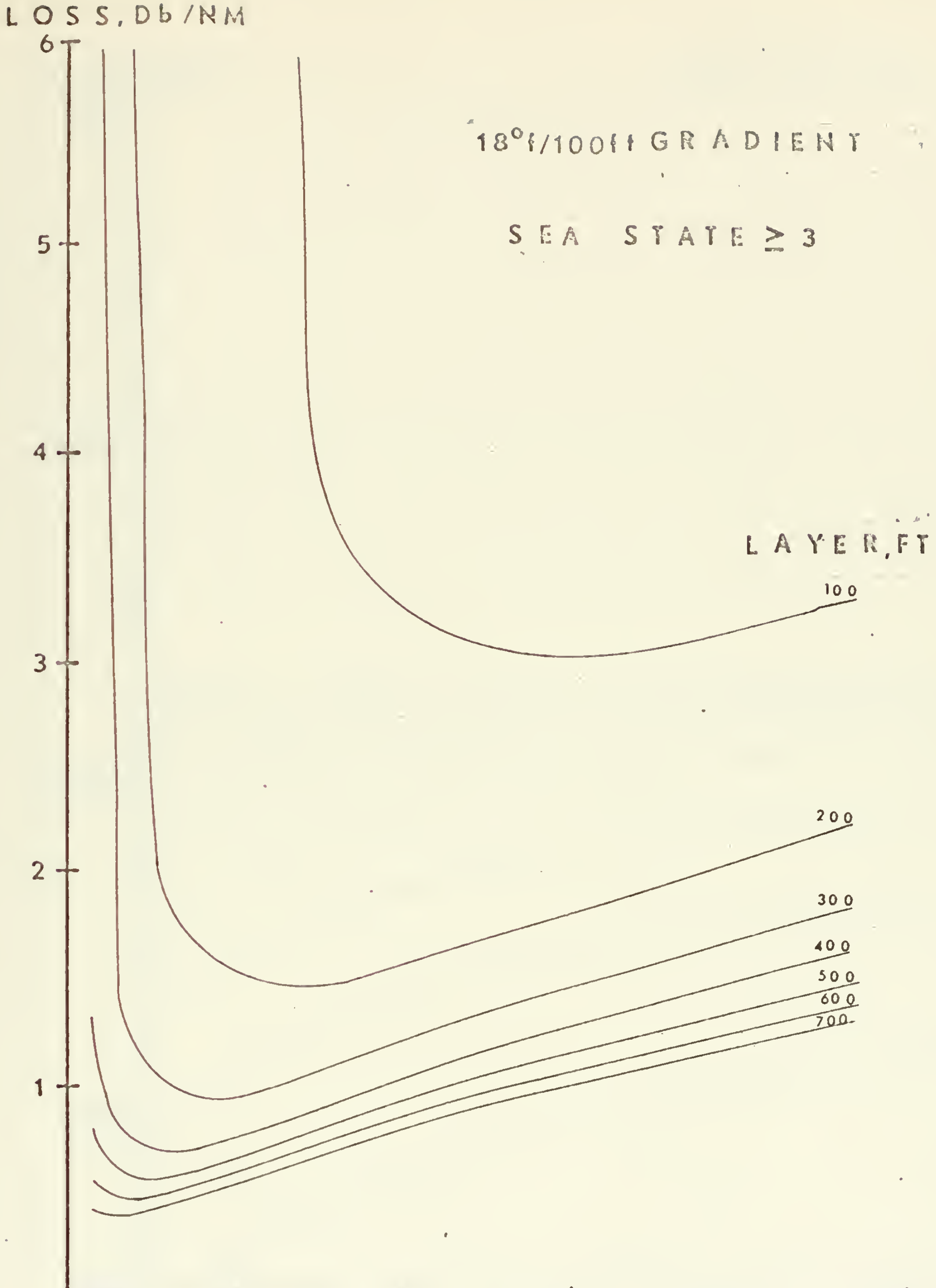


Figure A-8. Propagation loss for high sea state and a below layer gradient of -18°F/100 FT.

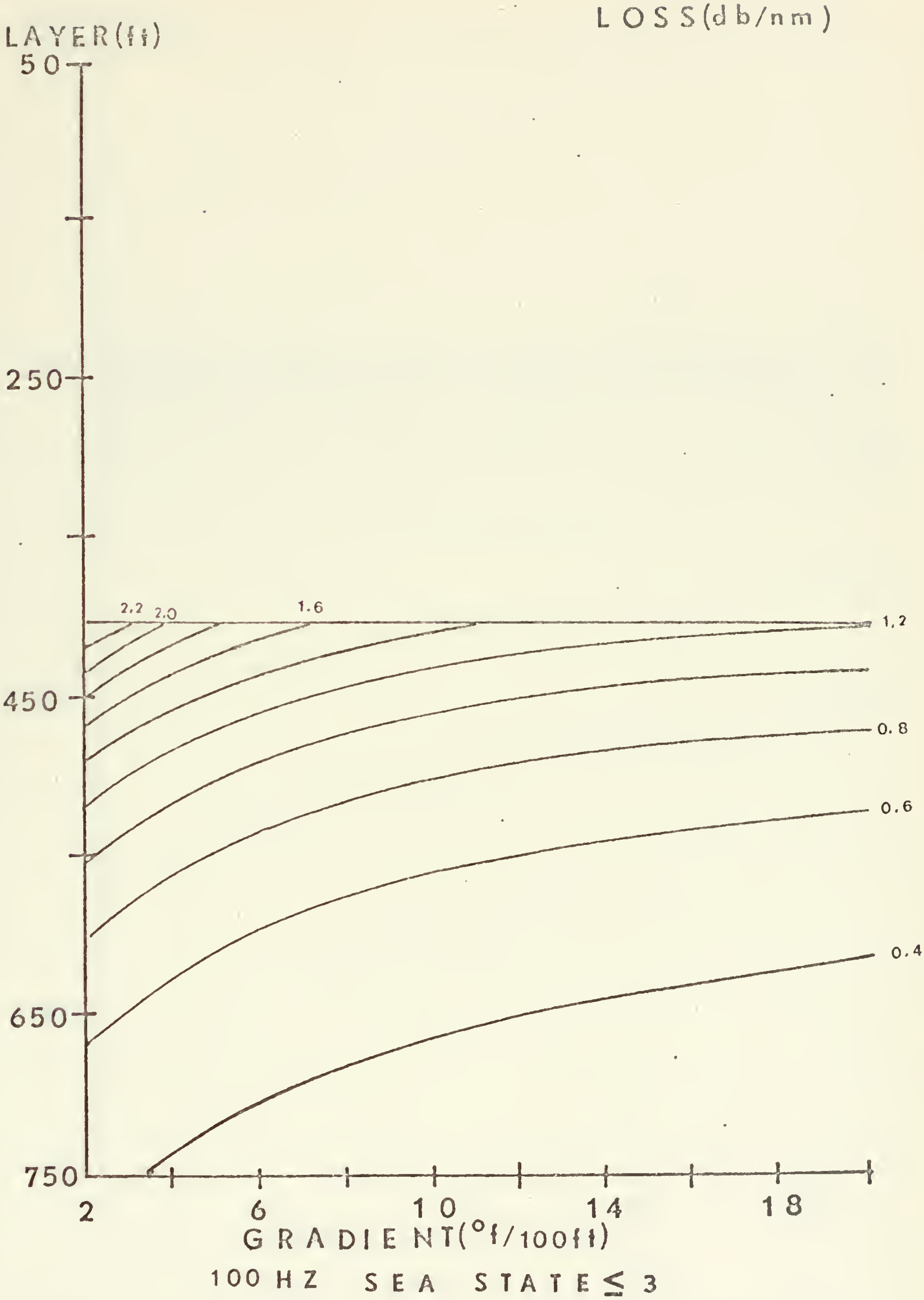


Figure A-9. Iso-loss contours for 100 HZ and low sea state.

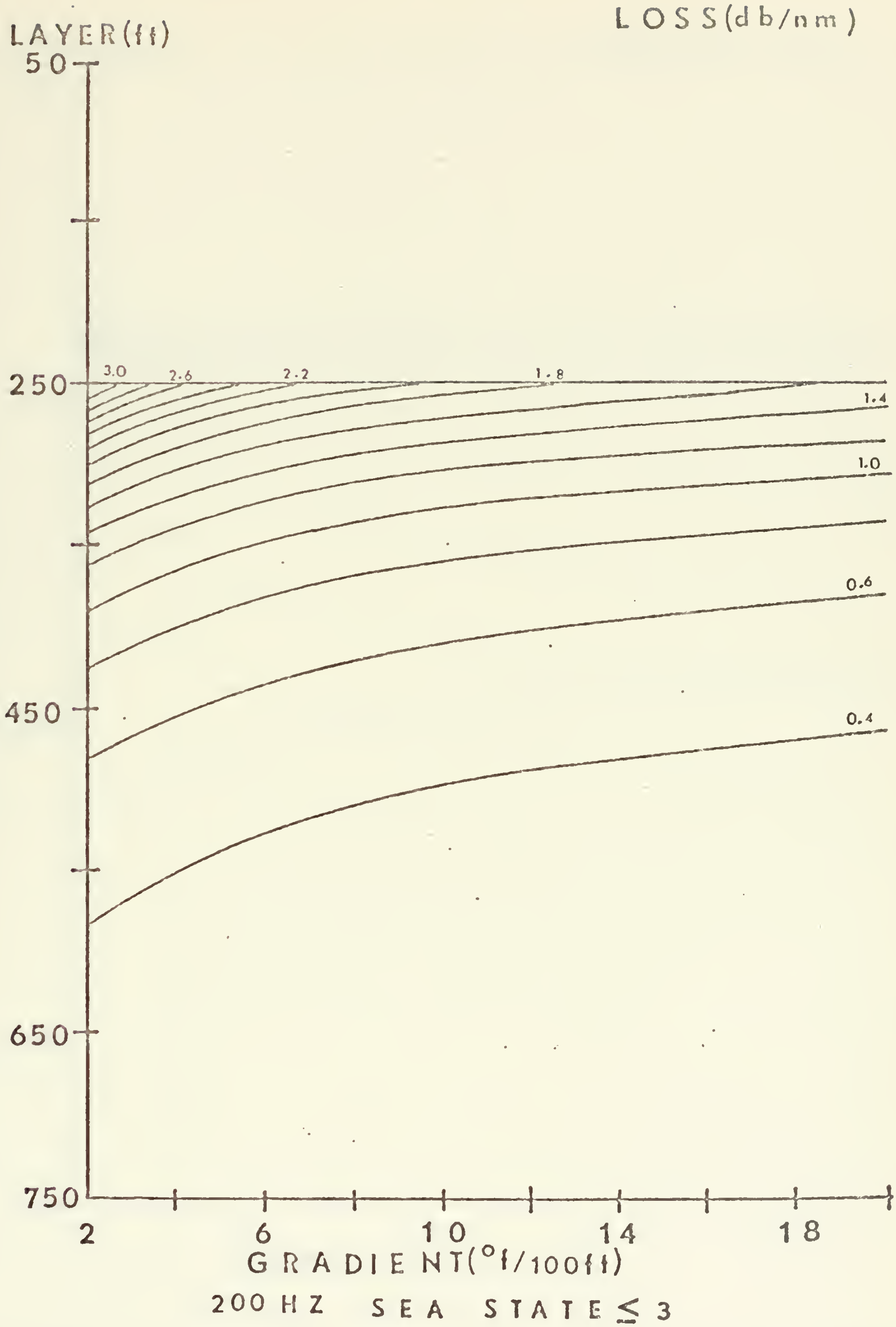


Figure A-10. Iso-loss contours for 200 HZ and low sea state.

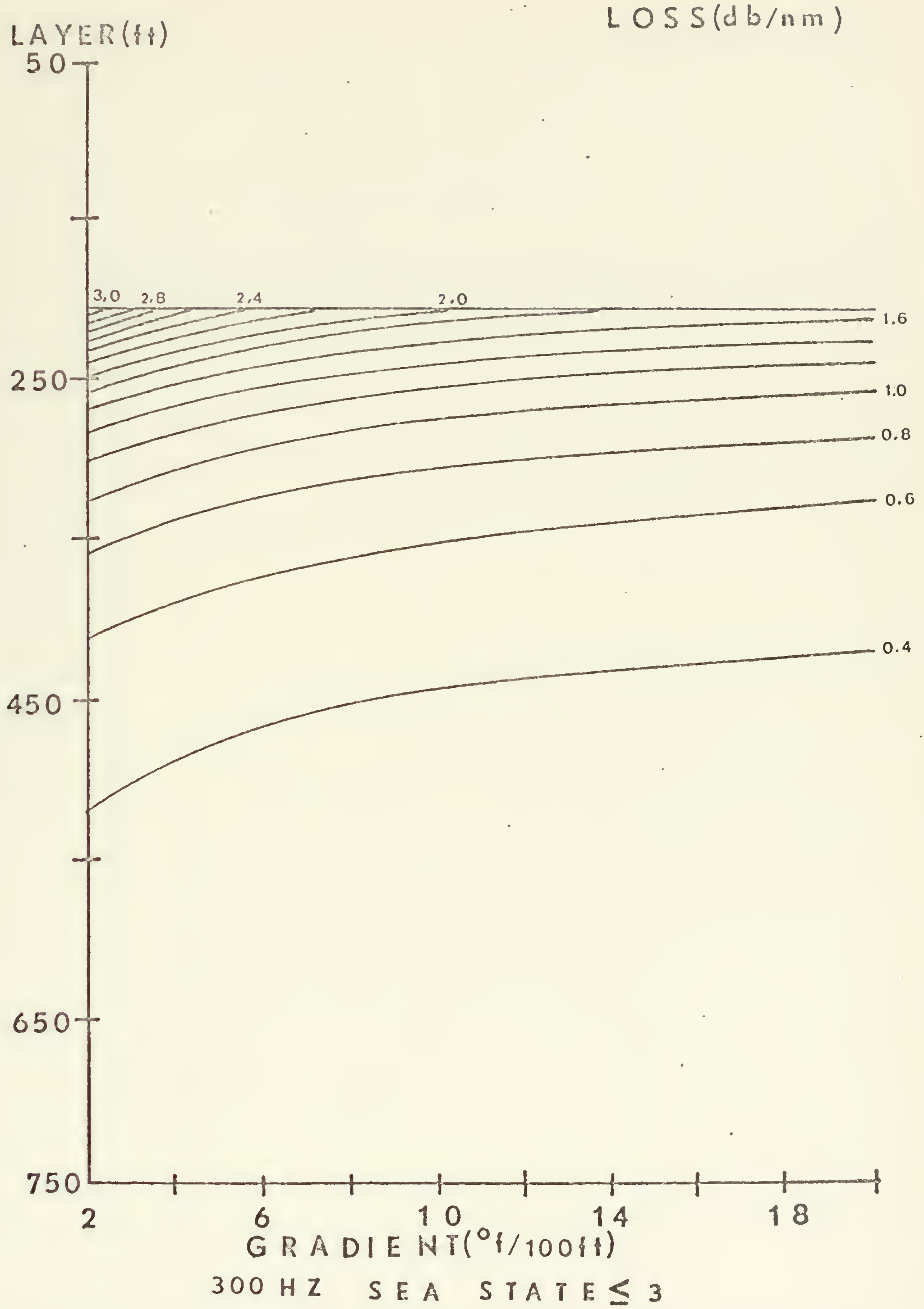


Figure A-11. Iso-loss contours for 300 HZ and low sea state.

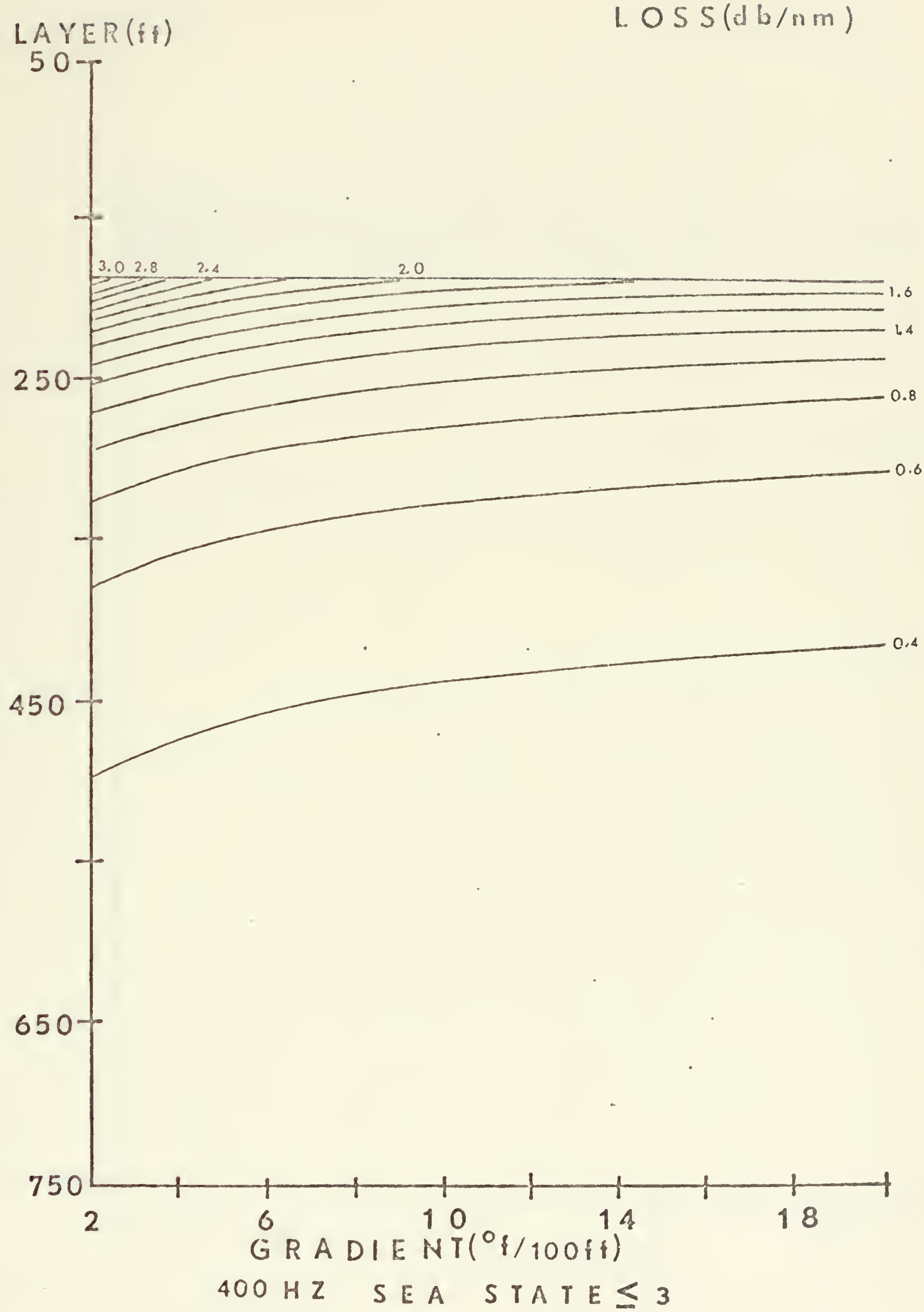


Figure A-12. Iso-loss contours for 400 HZ and low sea state.

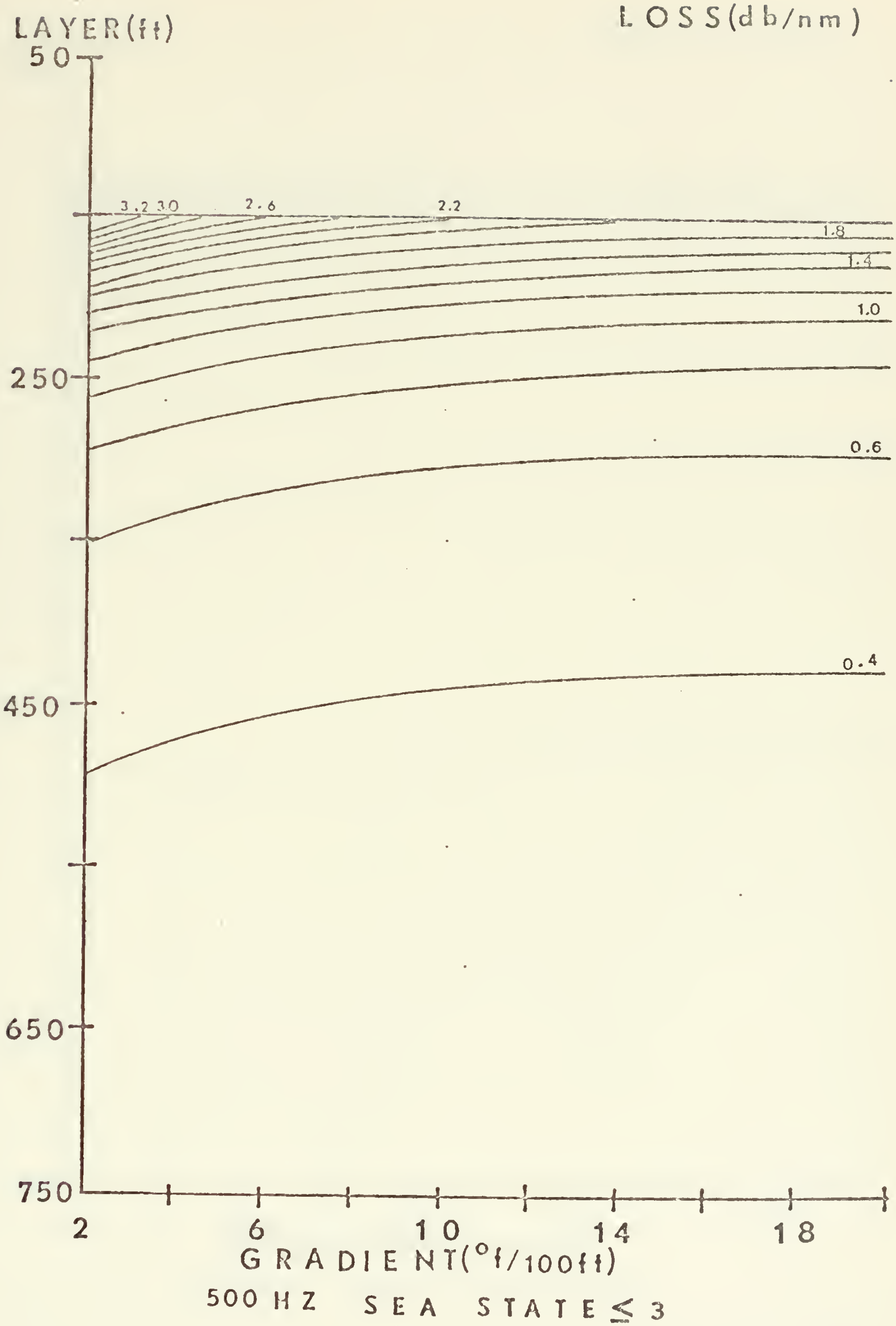


Figure A-13. Iso-loss contours for 500 HZ and low sea state.

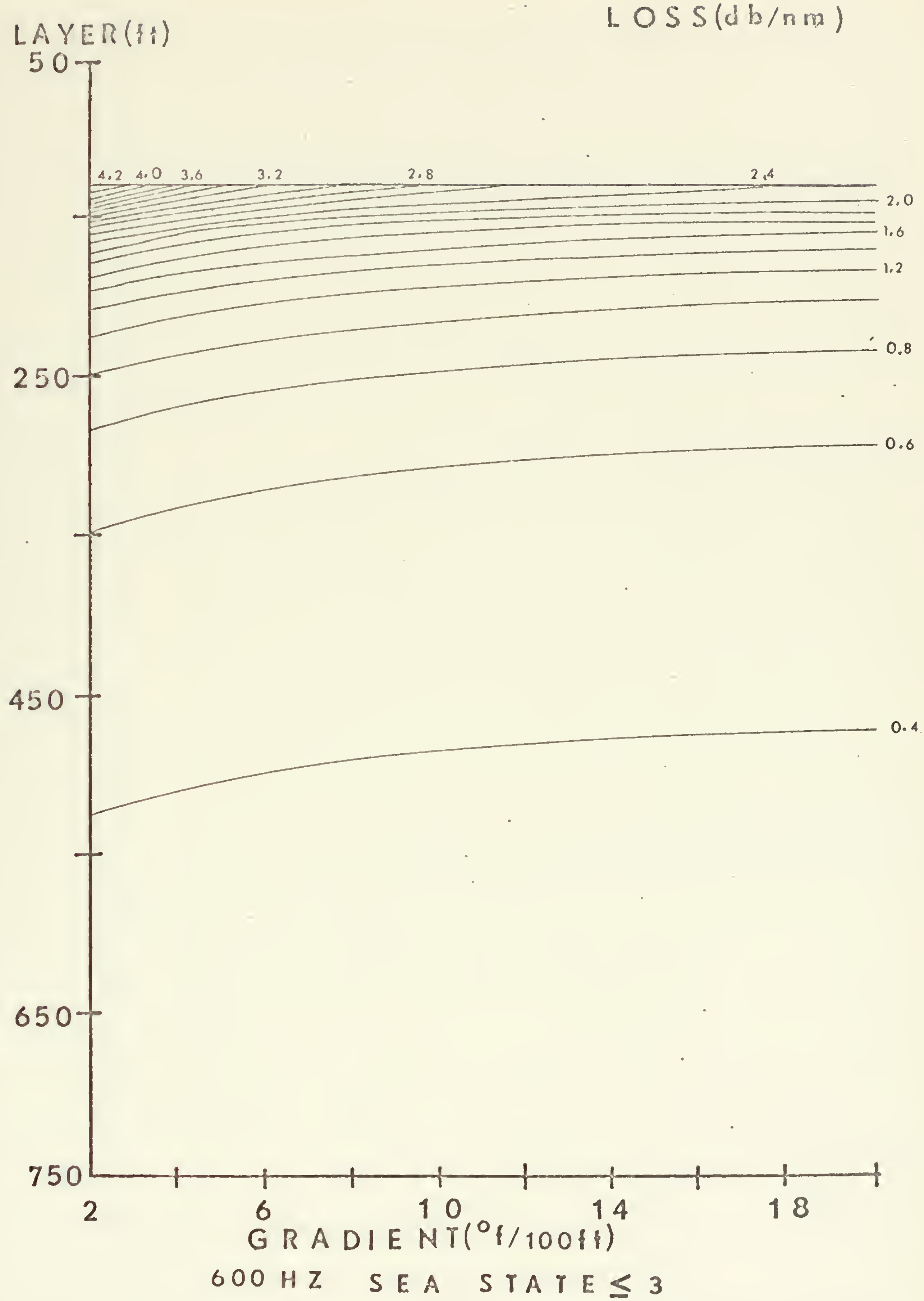


Figure A-14. Iso-loss contours for 600 HZ and low sea state.

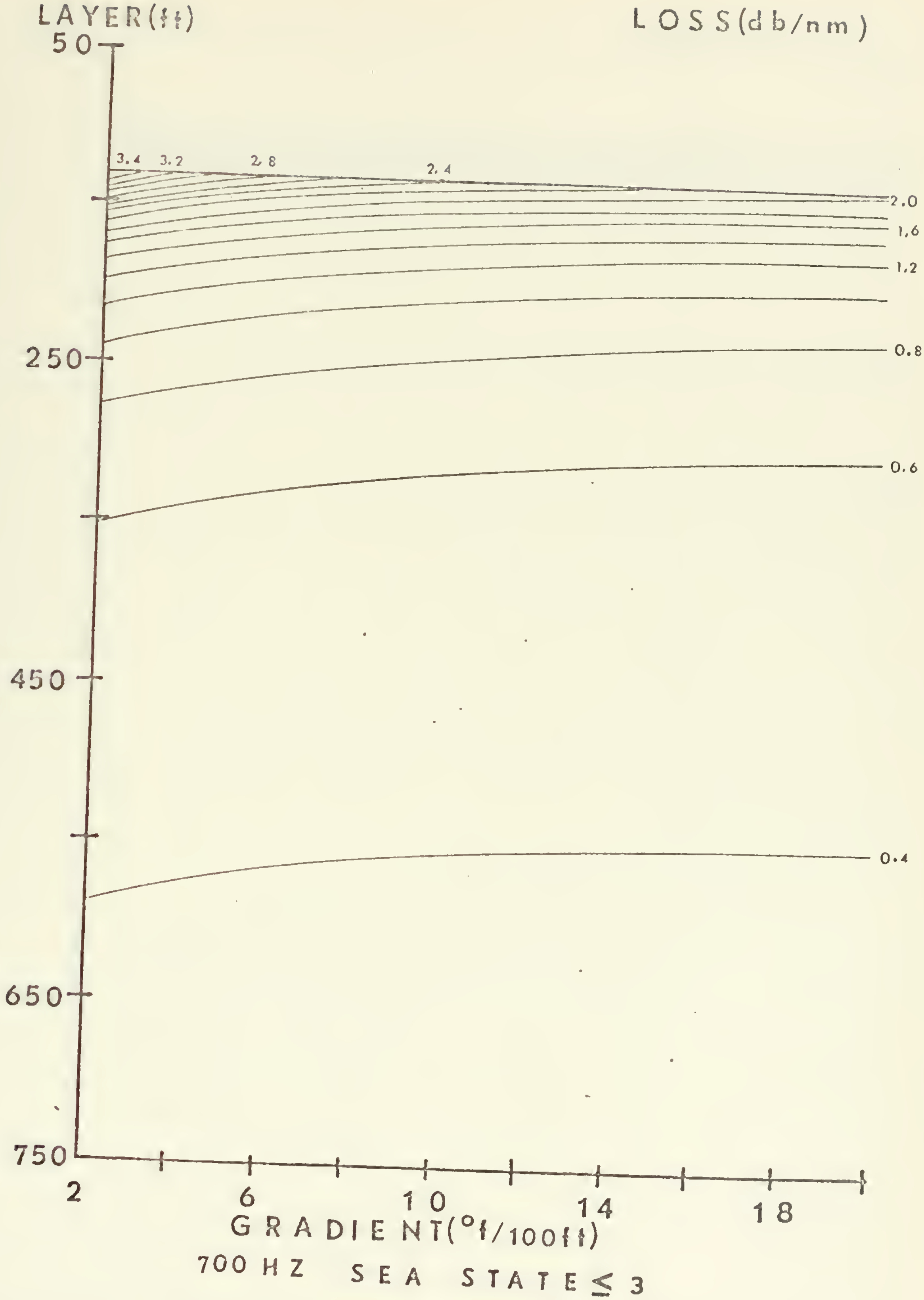


Figure A-15. Iso-loss contours for 700 HZ and low sea state.

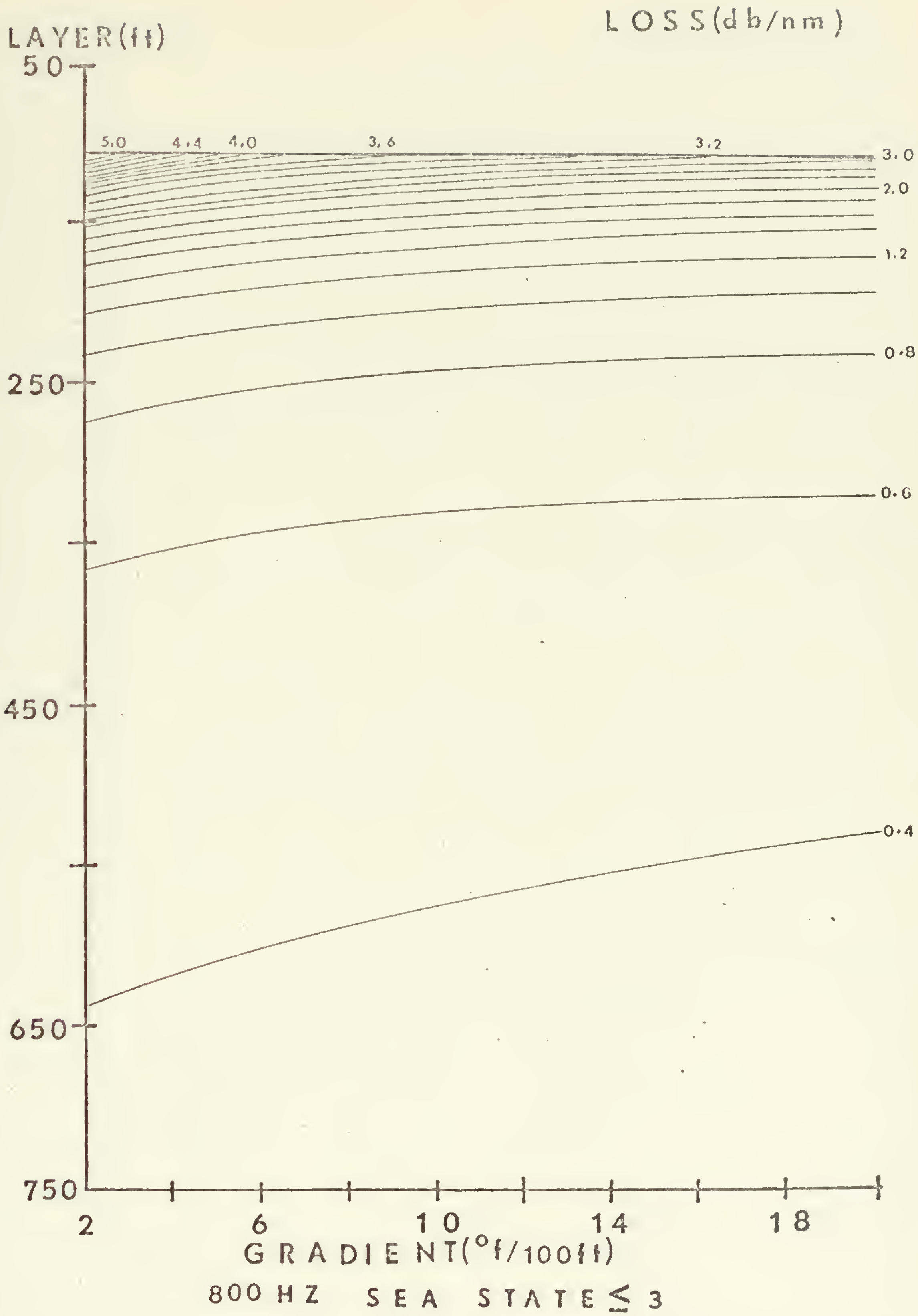


Figure A-16. Iso-loss contours for 800 HZ and low sea state.

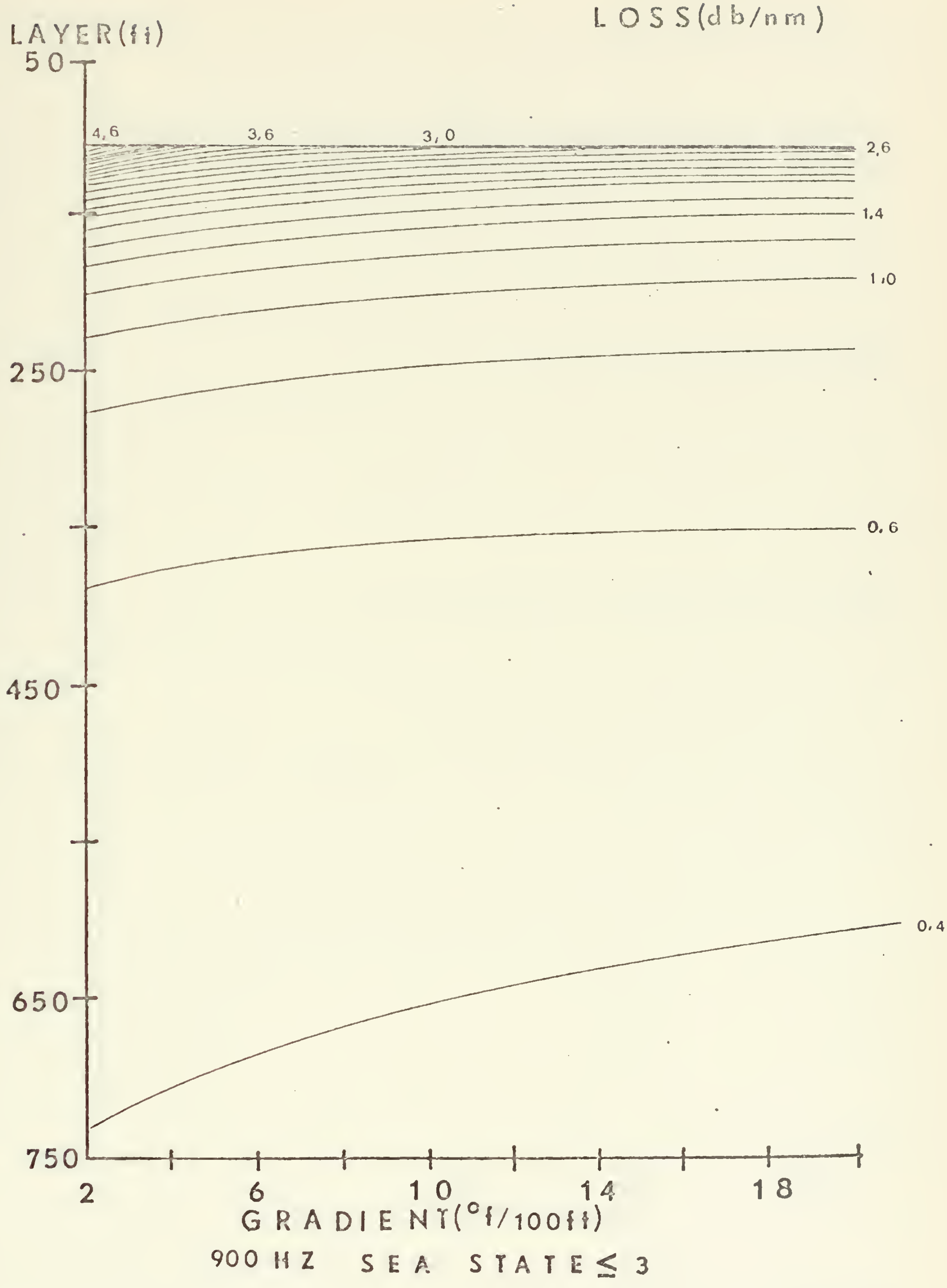


Figure A-17. Iso-loss contours for 900 HZ and low sea state.

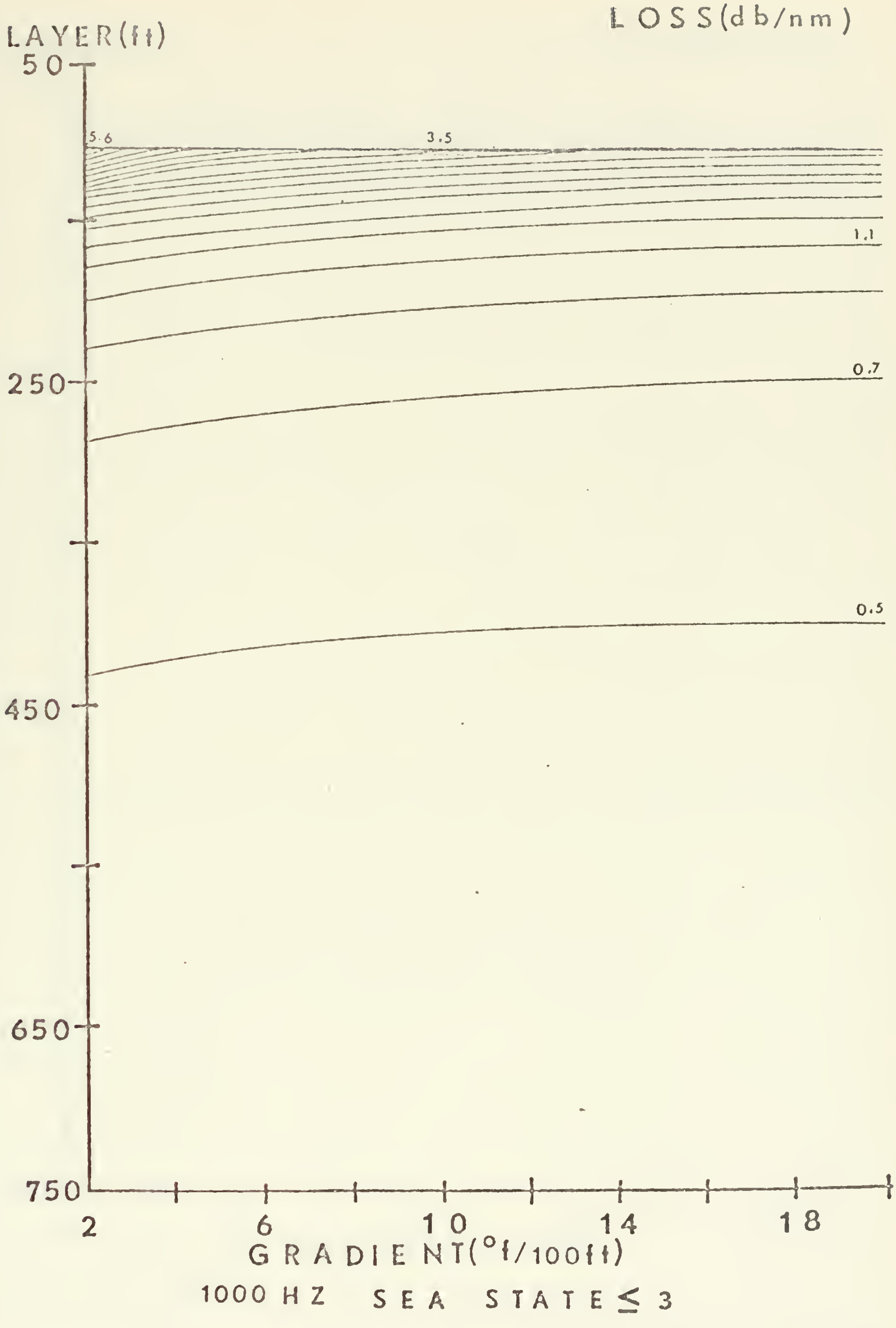


Figure A-18. Iso-loss contours for 1000 HZ and low sea state.

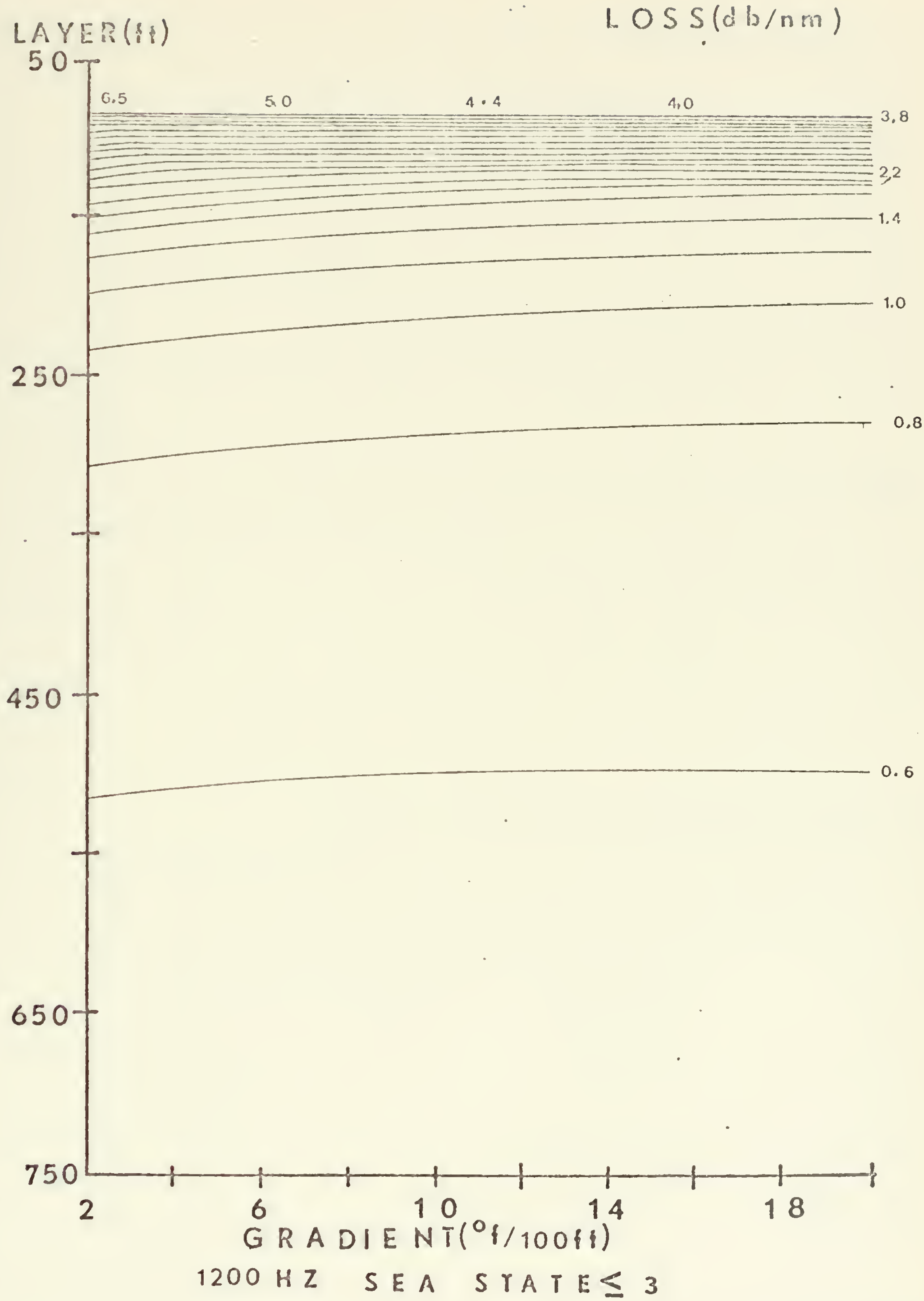


Figure A-19. Iso-loss contours for 1200 HZ and low sea state.

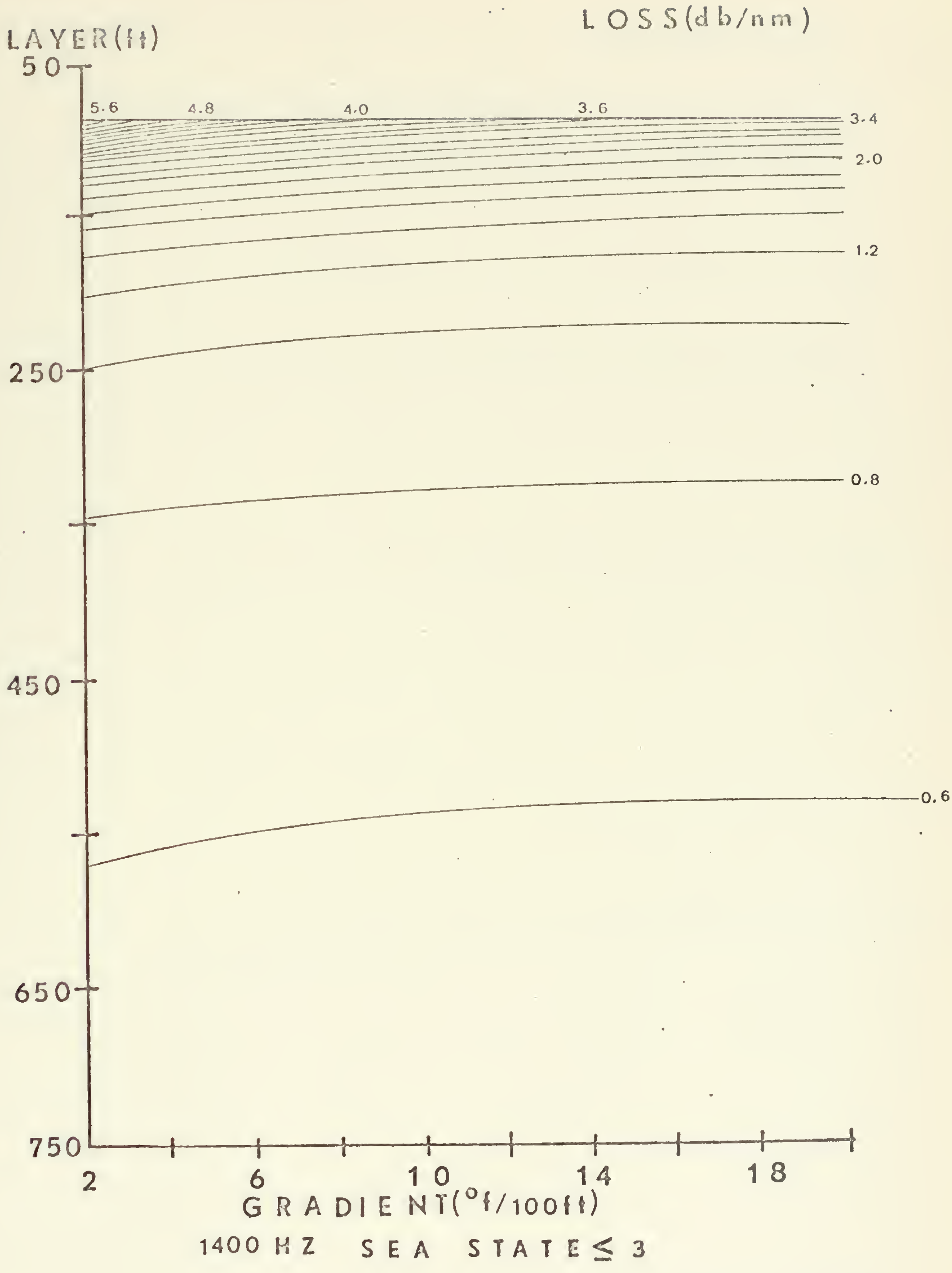


Figure A-20. Iso-loss contours for 1400 HZ and low sea state.

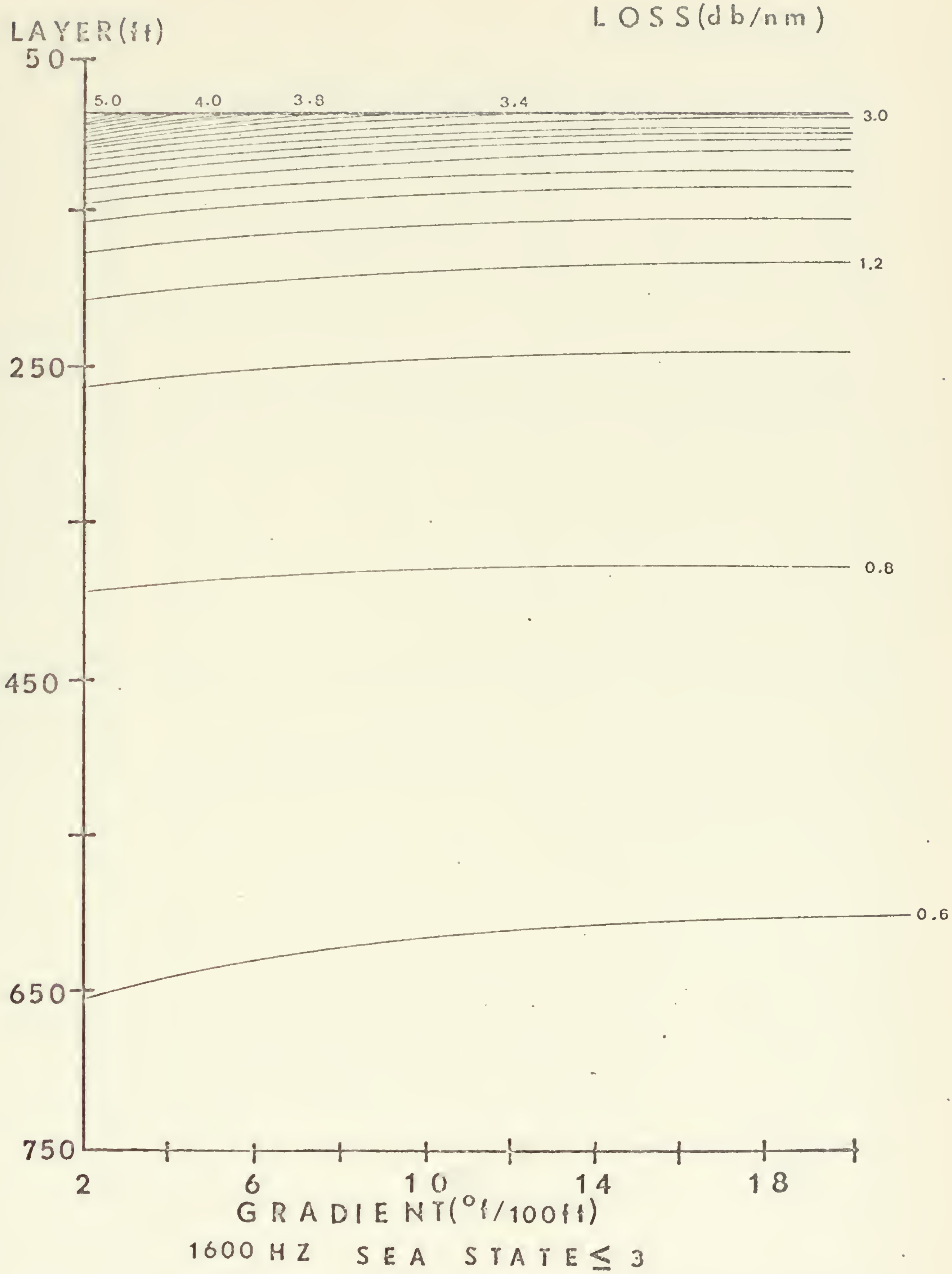


Figure A-21. Iso-loss contours for 1600 HZ and low sea state.

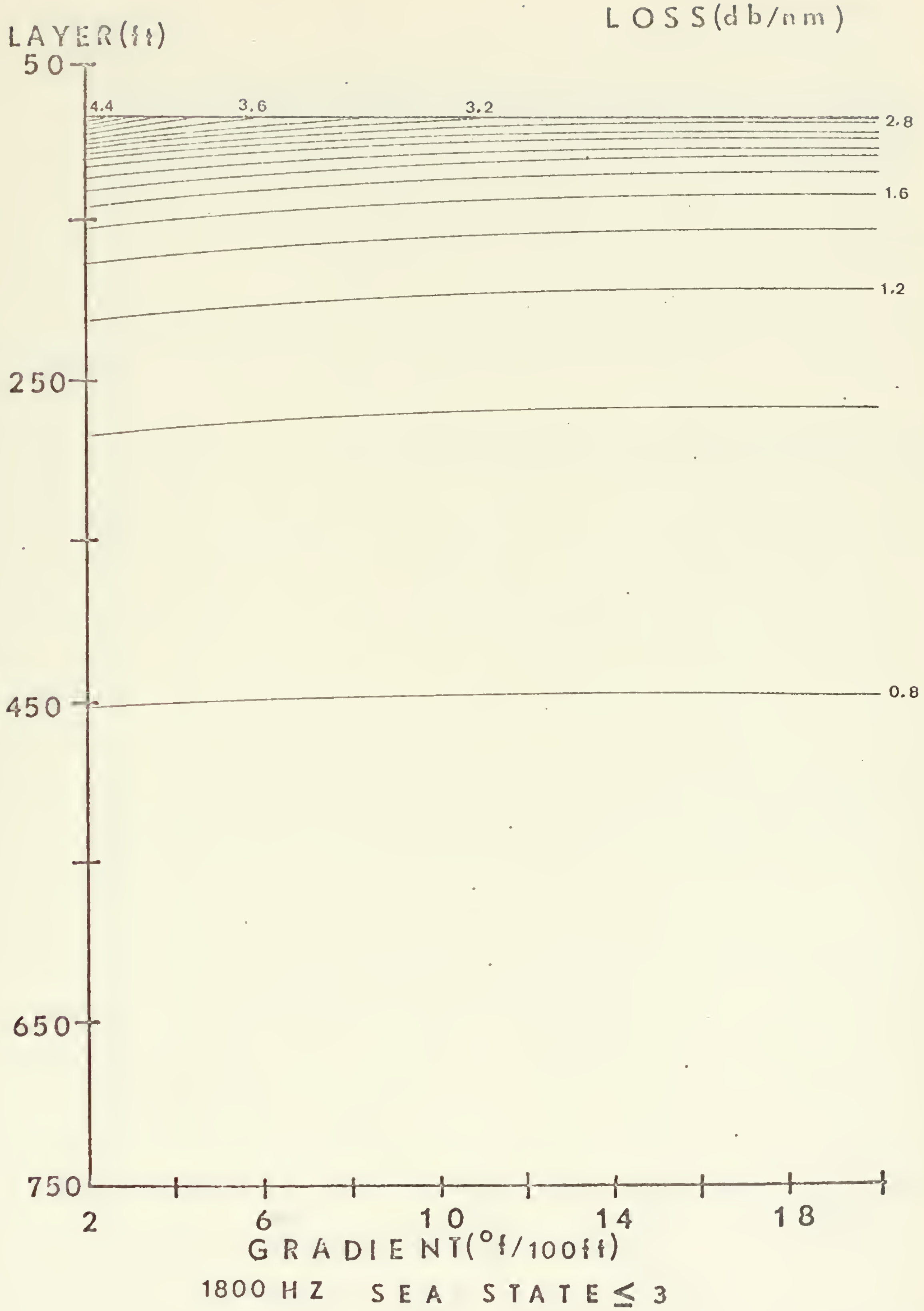


Figure A-22. Iso-loss contours for 1800 HZ and low sea state.

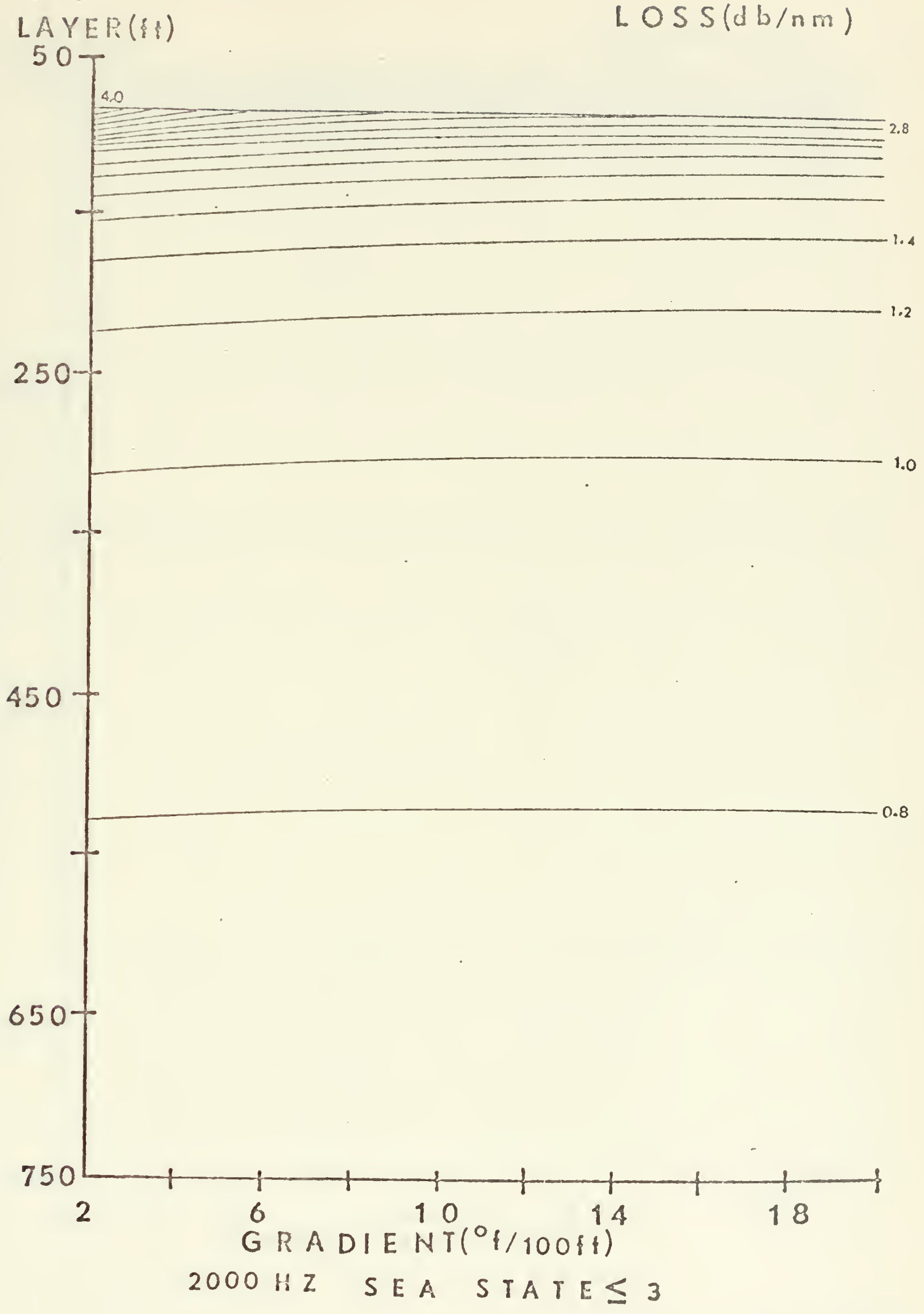


Figure A-23. Iso-loss contours for 2000 HZ and low sea state.

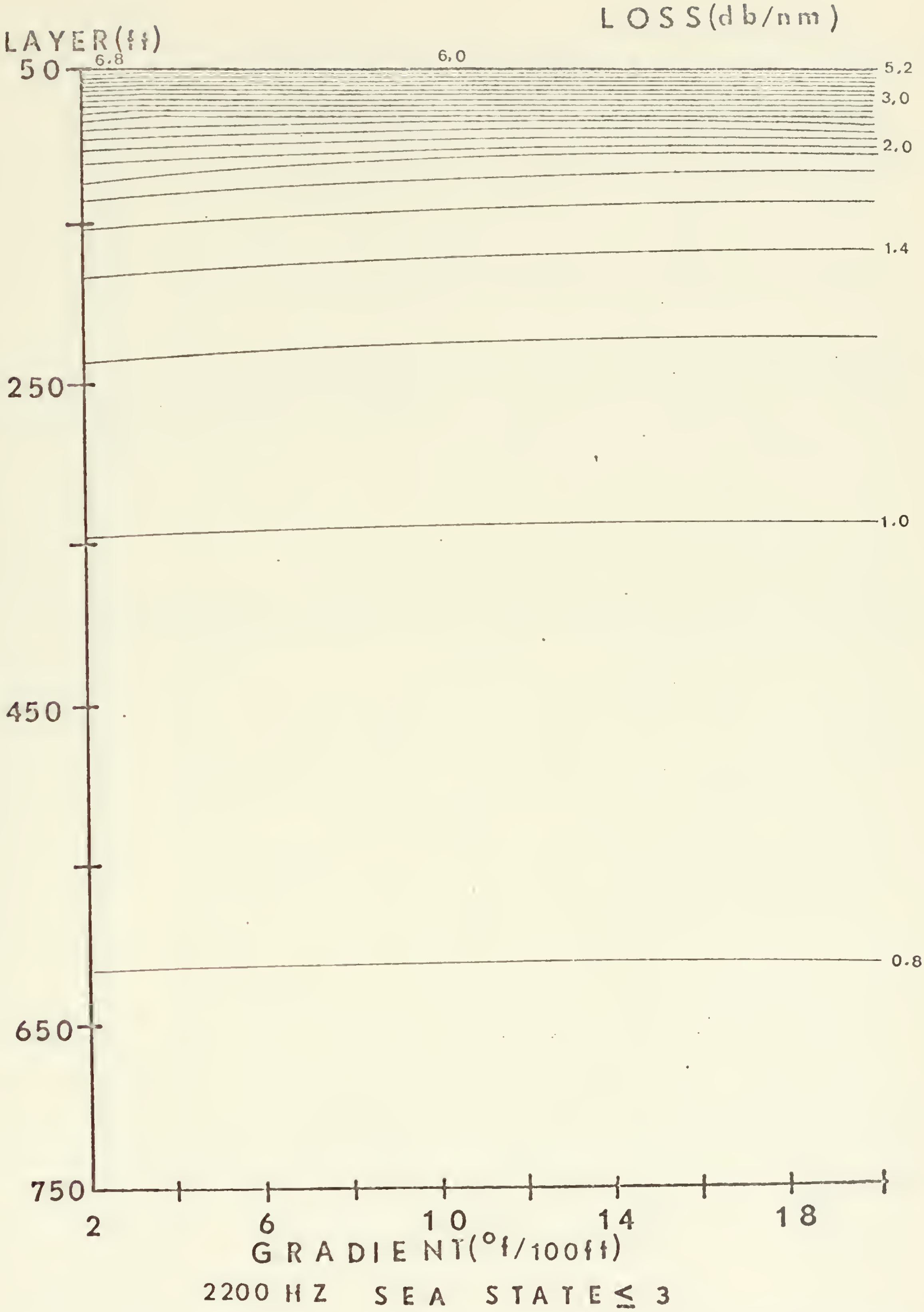


Figure A-24. Iso-loss contours for 2200 HZ and low sea state.

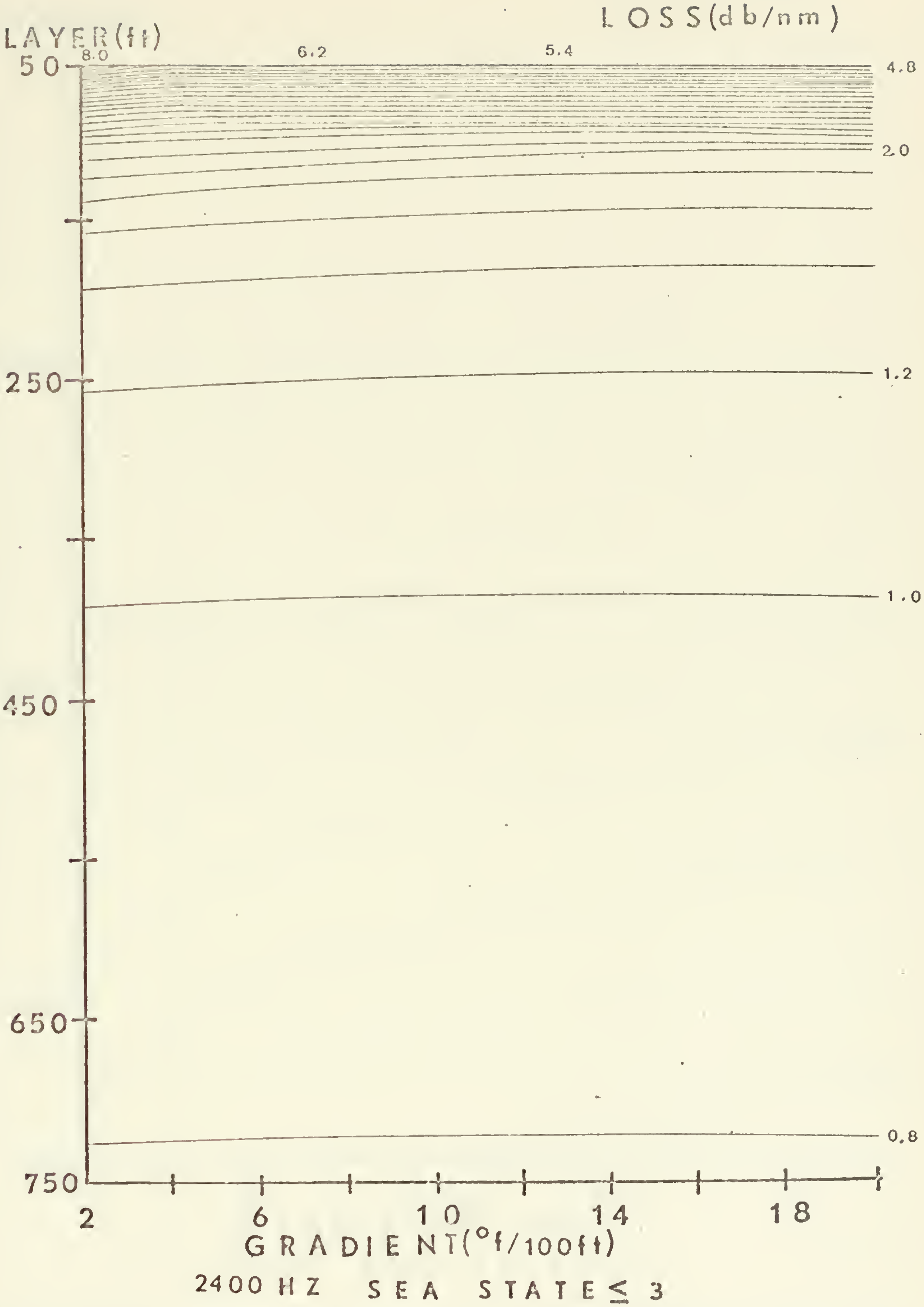


Figure A-25. Iso-loss contours for 2400 HZ and low sea state.

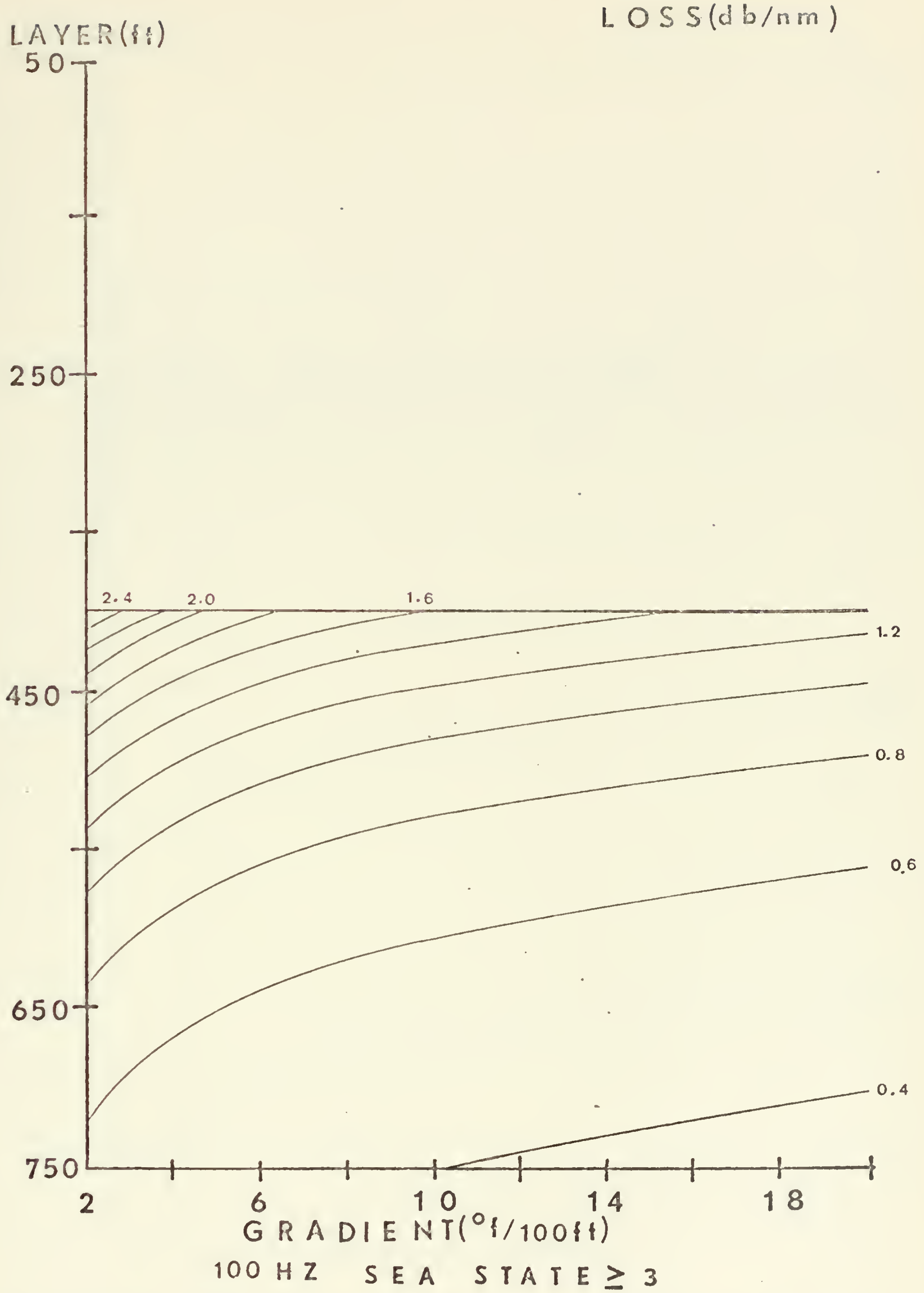


Figure A-26. Iso-loss contours for 100 HZ and high sea state.

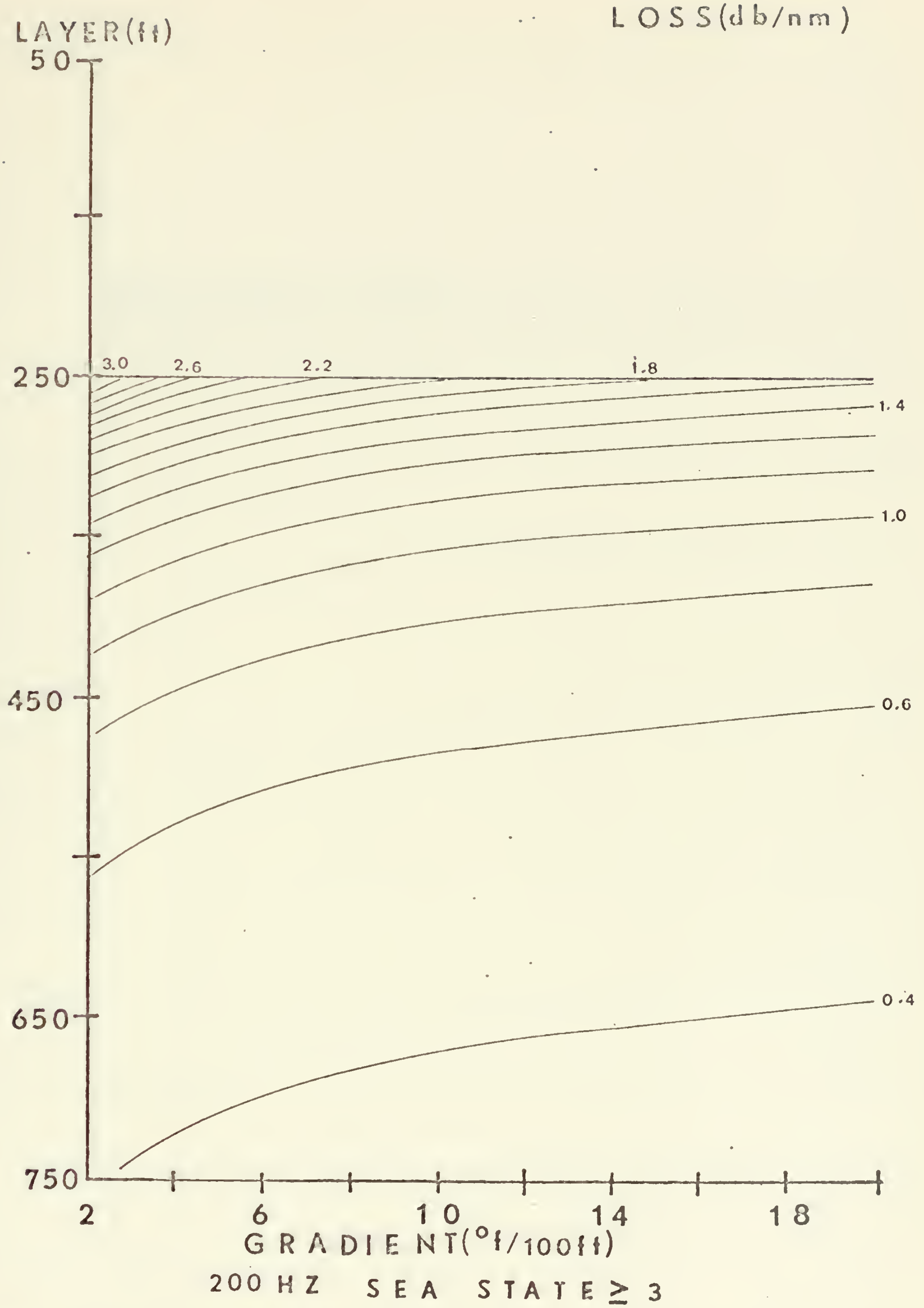


Figure A-27. Iso-loss contours for 200 HZ and high sea state.

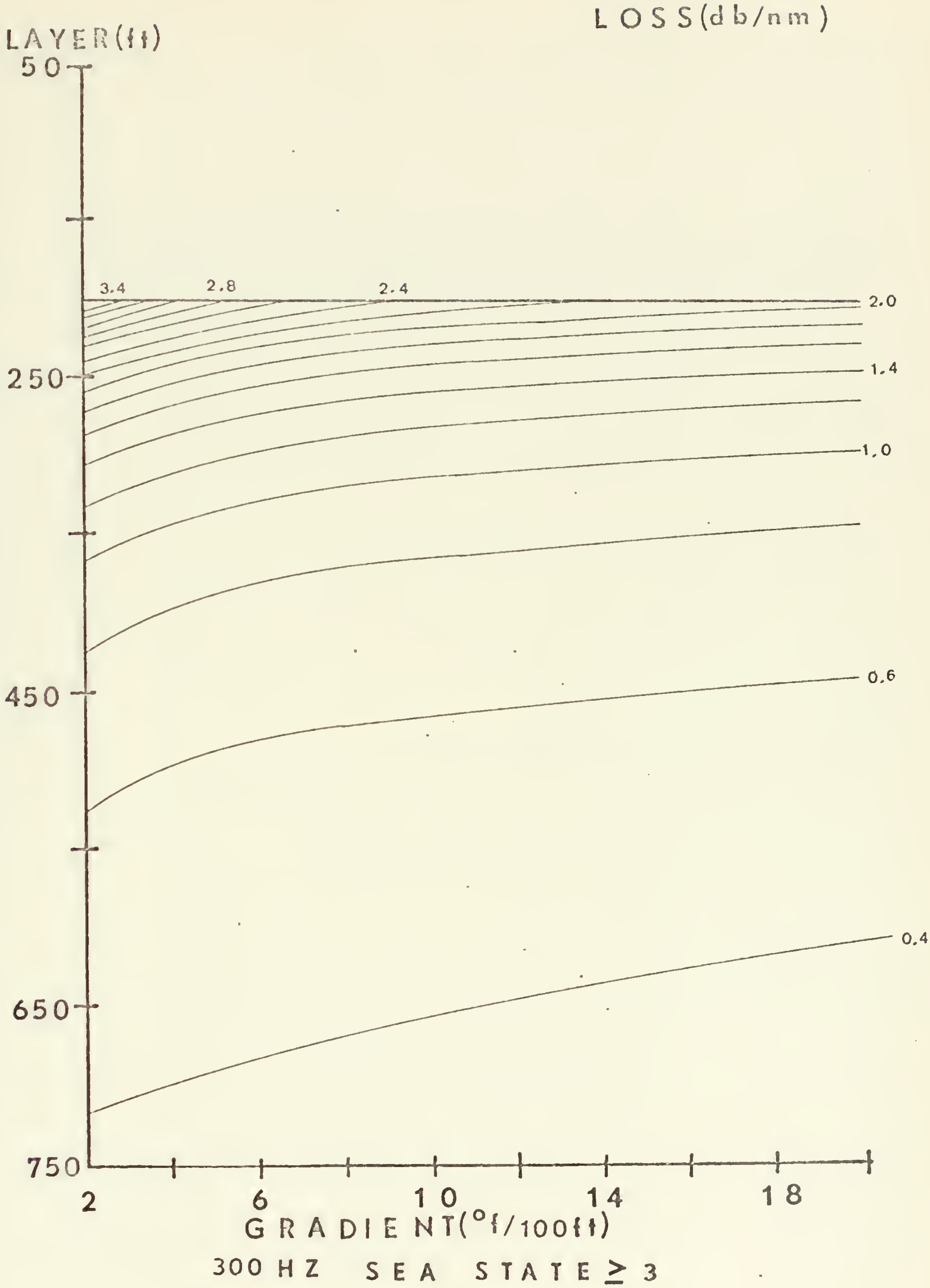


Figure A-28. Iso-loss contours for 300 HZ and high sea state.

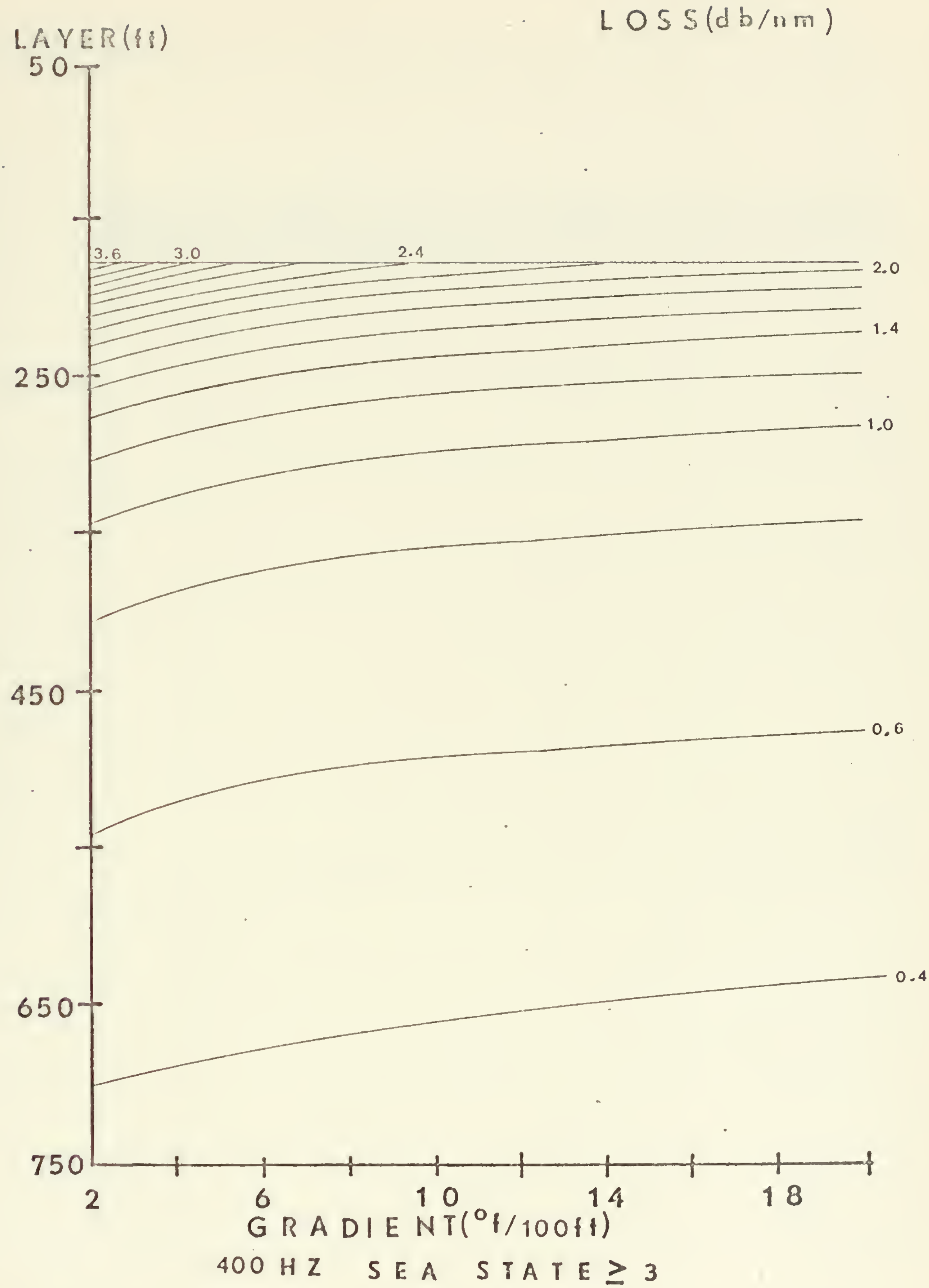


Figure A-29. Iso-loss contours for 400 HZ and high sea state.

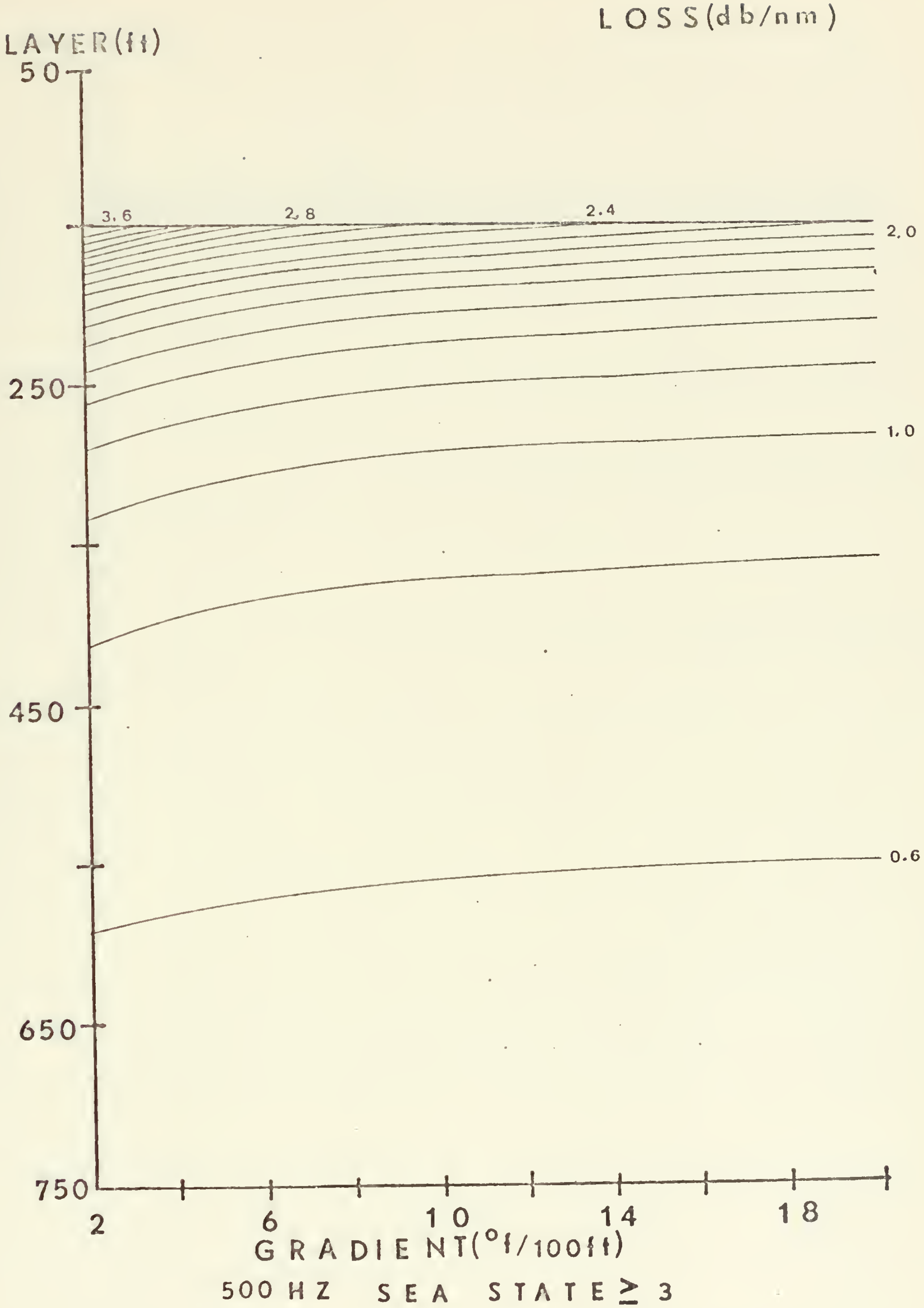


Figure A-30. Iso-loss contours for 500 HZ and high sea state.

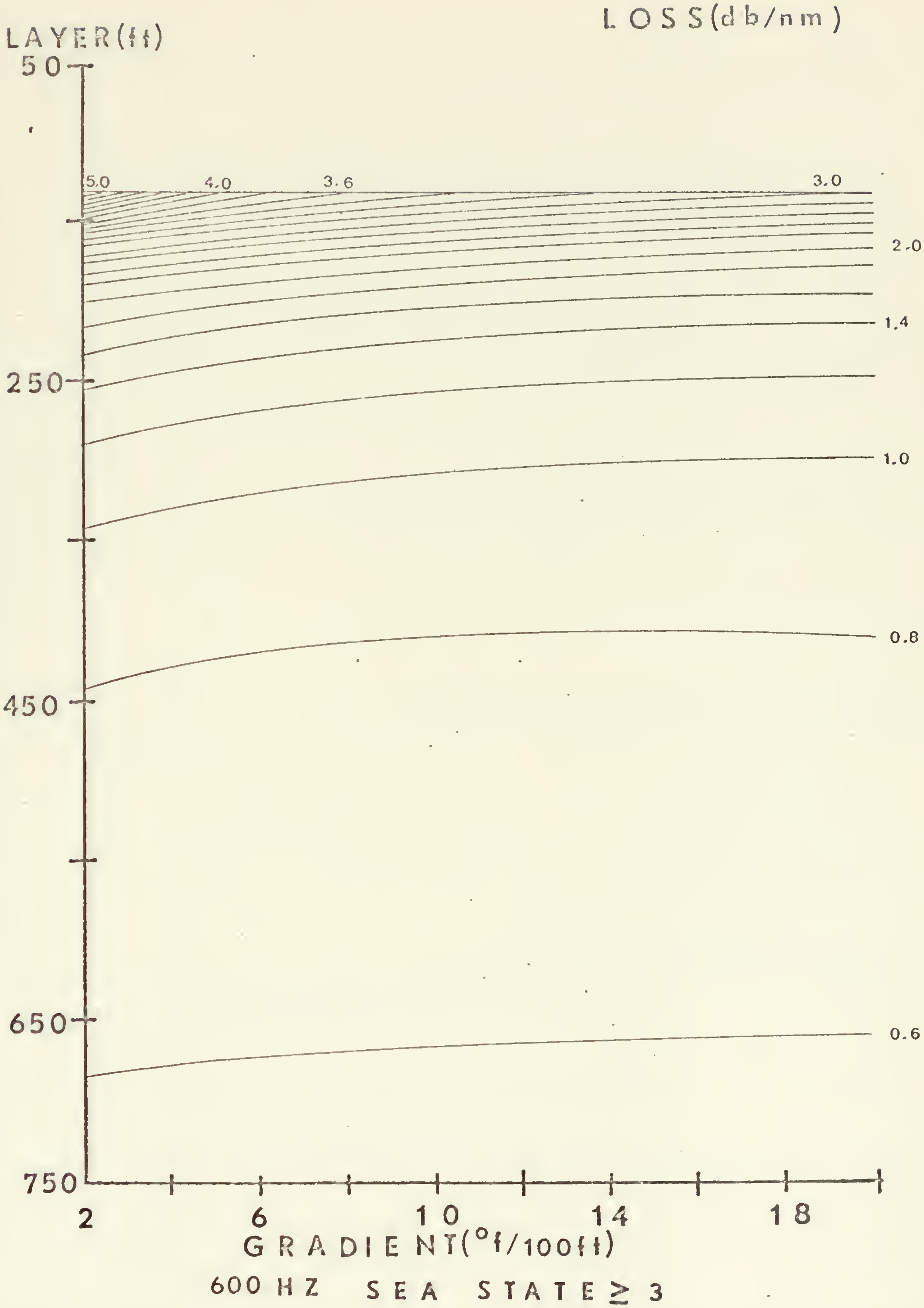


Figure A-31. Iso-loss contours for 600 HZ and high sea state.

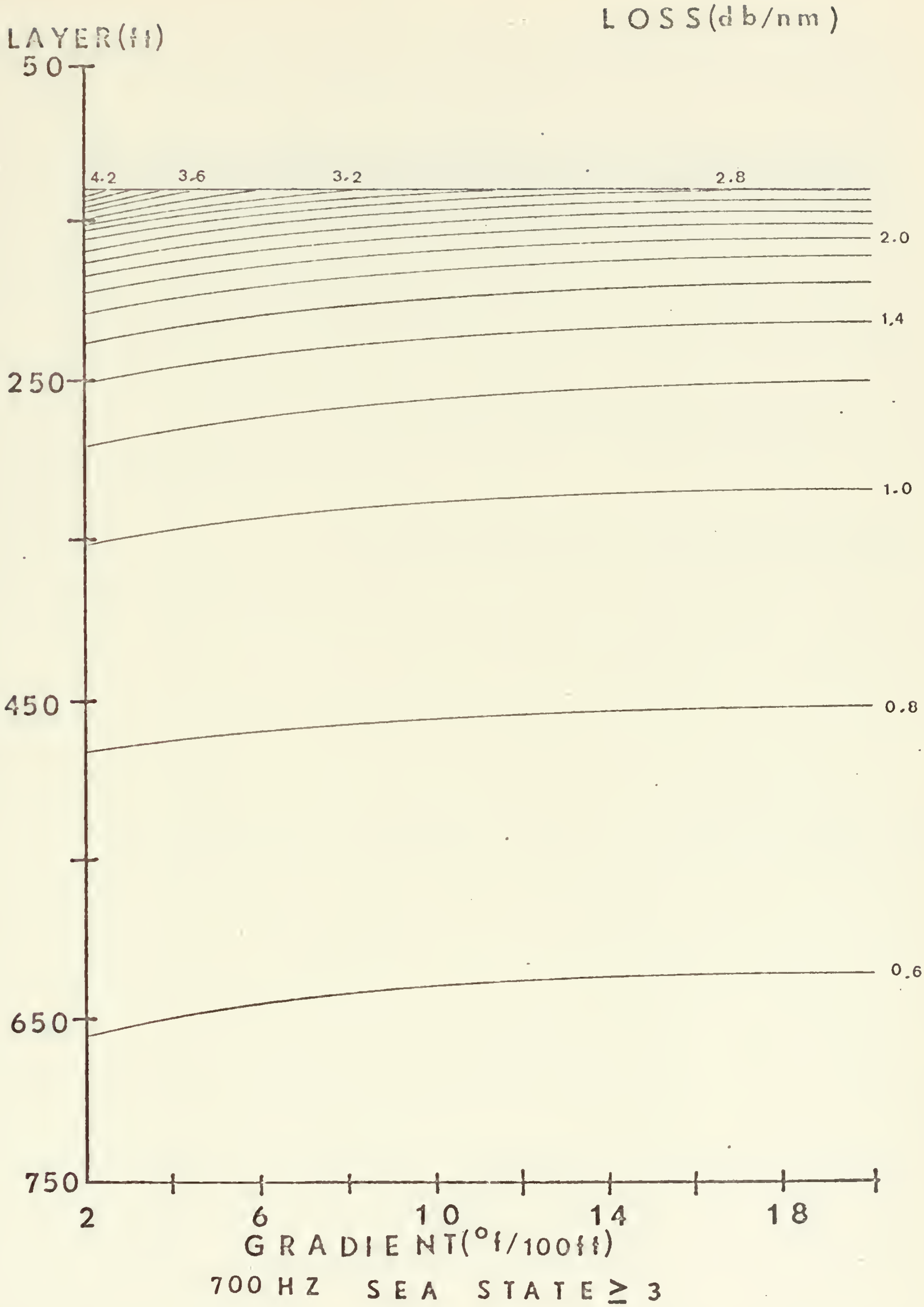


Figure A-32. Iso-loss contours for 700 HZ and high sea state.

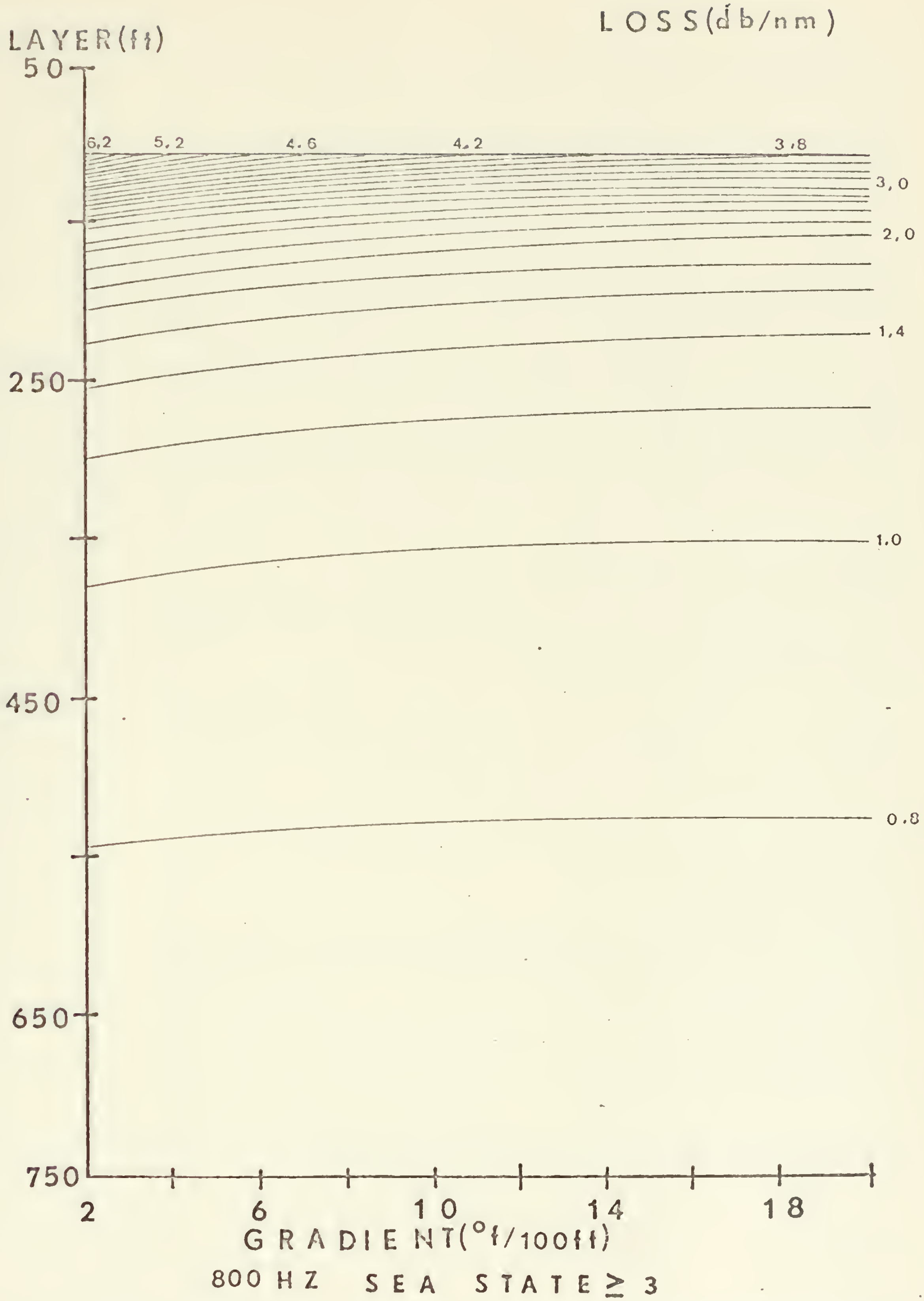


Figure A-33. Iso-loss contours for 800 HZ and high sea state.

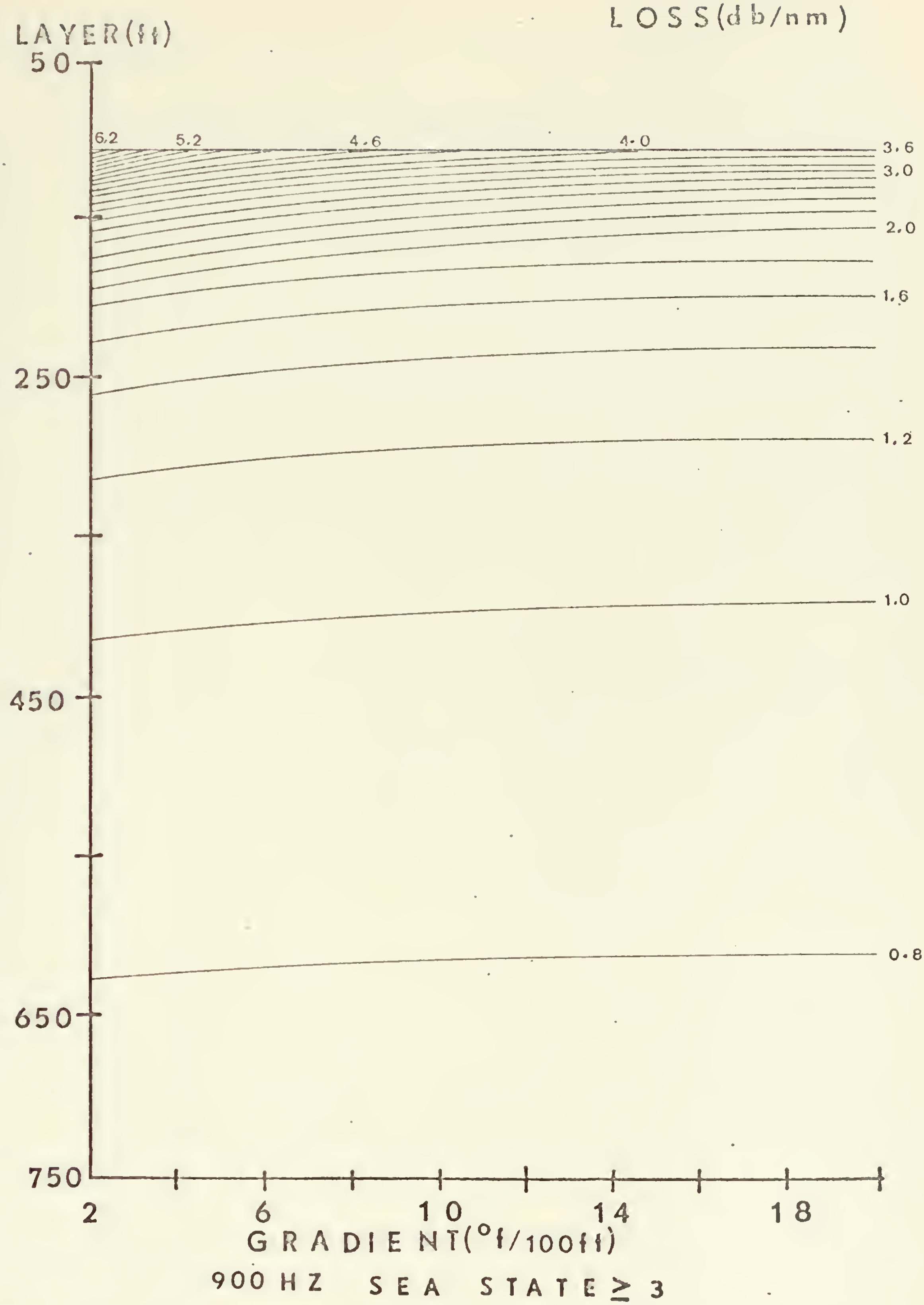


Figure A-34. Iso-loss contours for 900 HZ and high sea state.

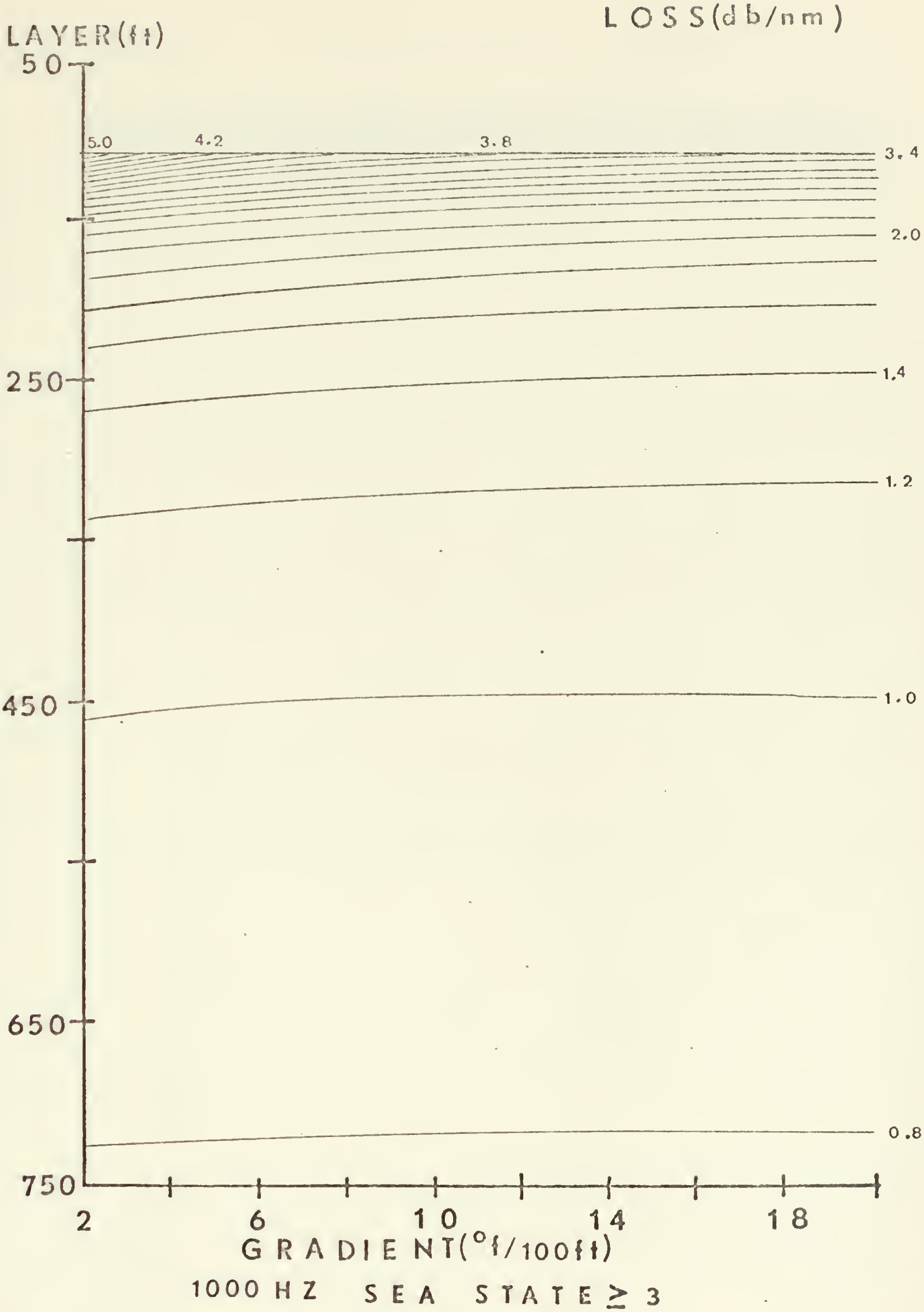


Figure A-35. Iso-loss contours for 1000 HZ and high sea state.

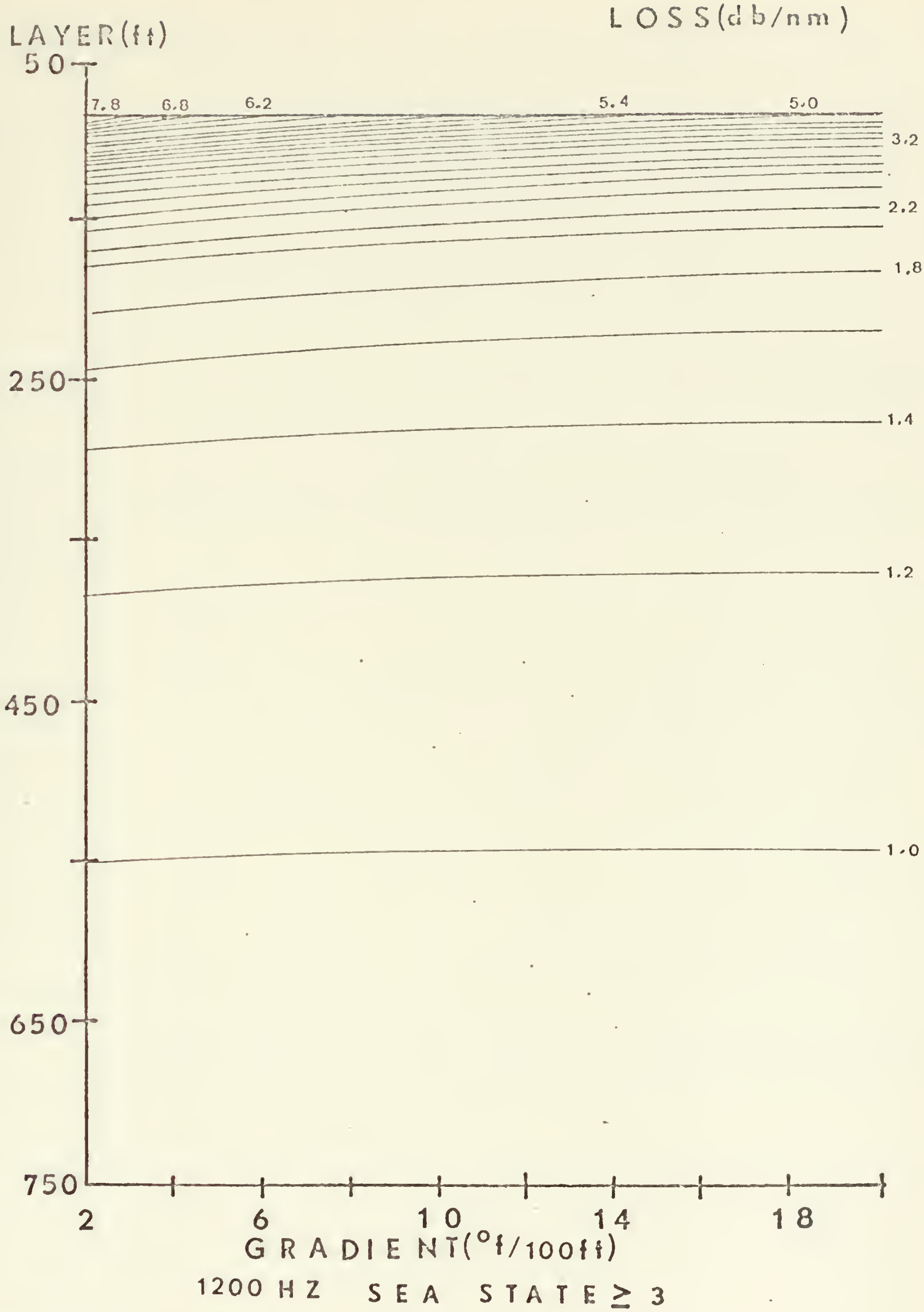


Figure A-36. Iso-loss contours for 1200 HZ and high sea state.

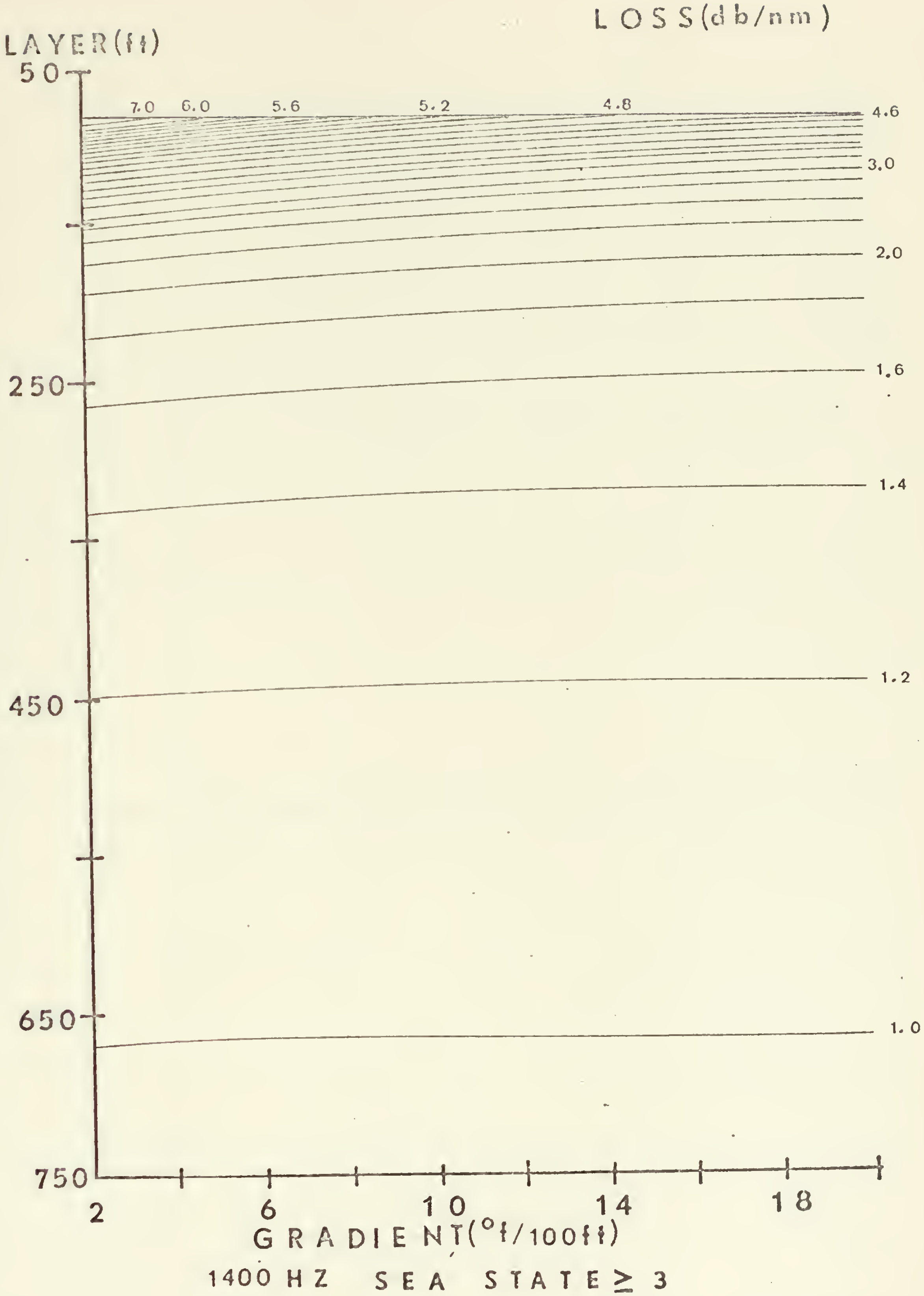


Figure A-37. Iso-loss contours for 1400 HZ and high sea state.

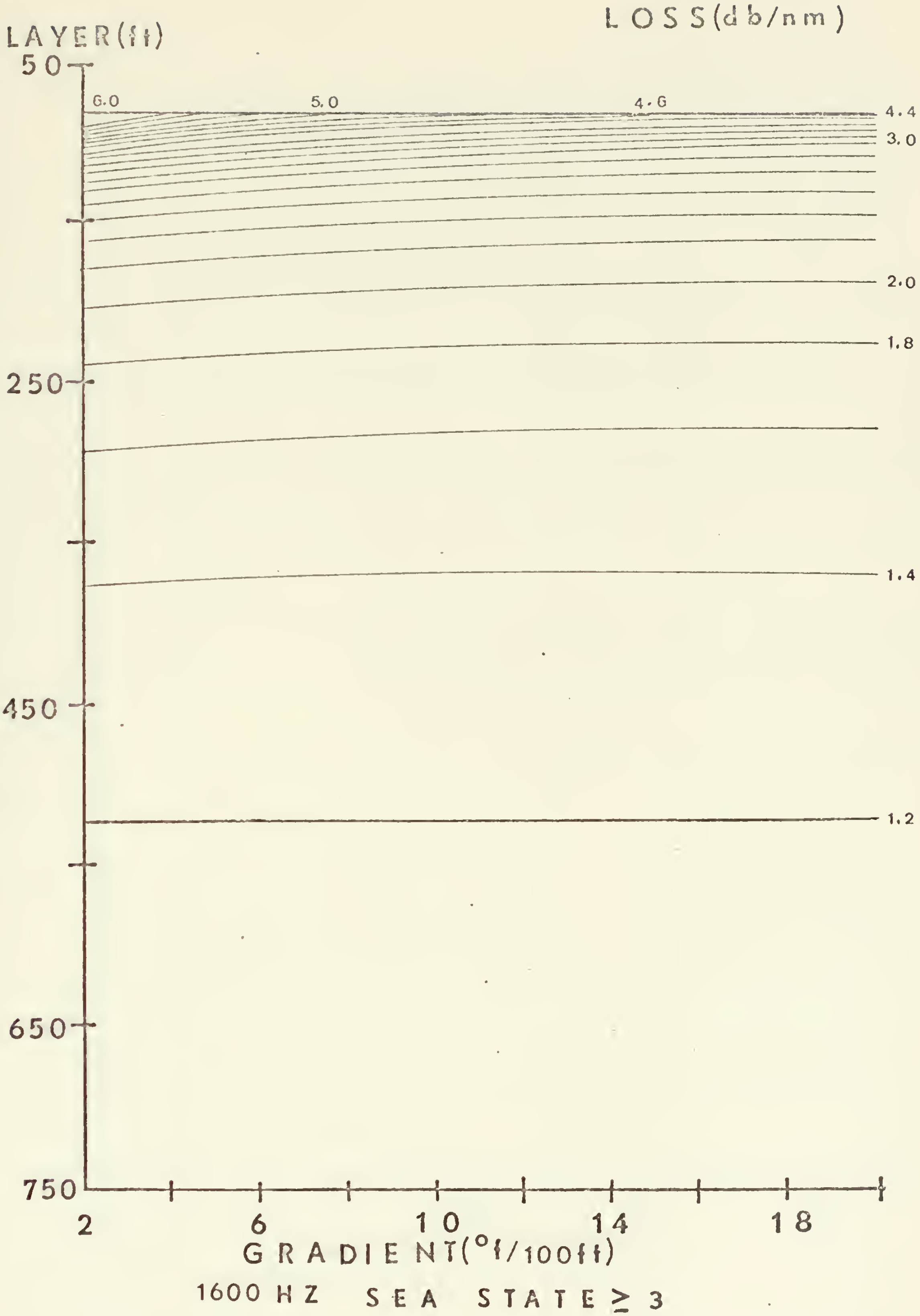


Figure A-38. Iso-loss contours for 1600 HZ and high sea state.

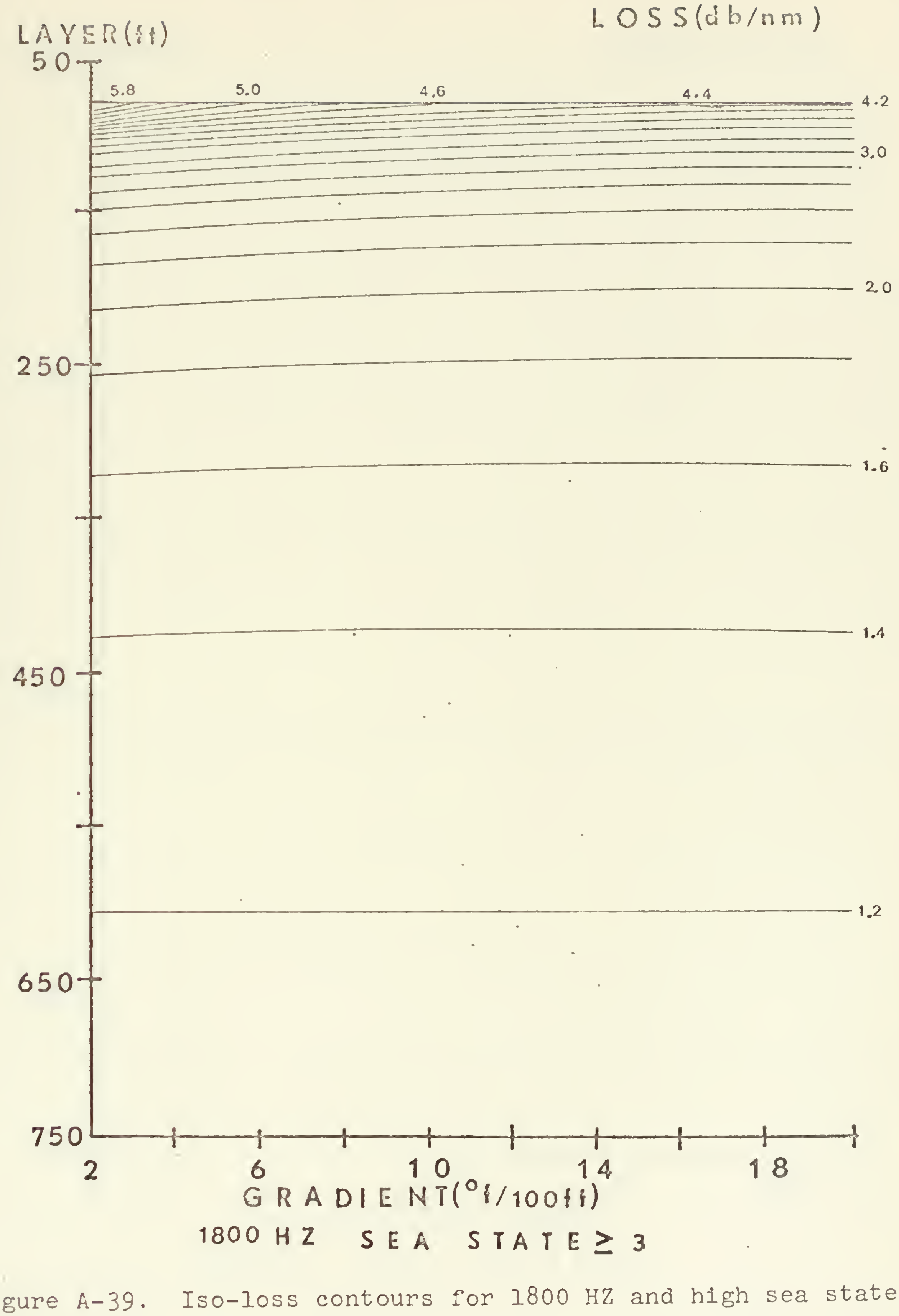


Figure A-39. Iso-loss contours for 1800 HZ and high sea state.

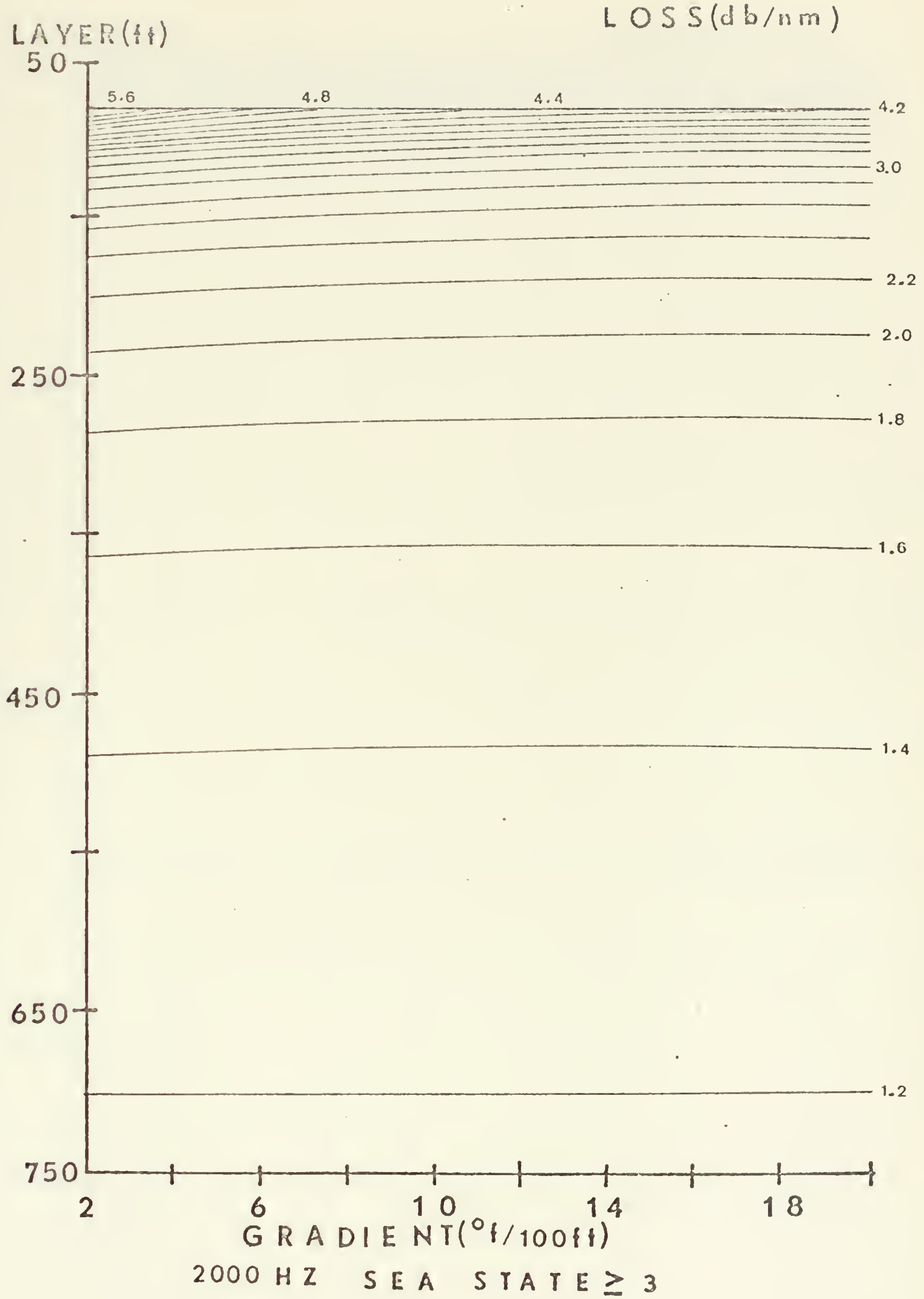


Figure A-40. Iso-loss contours for 2000 HZ and high sea state.

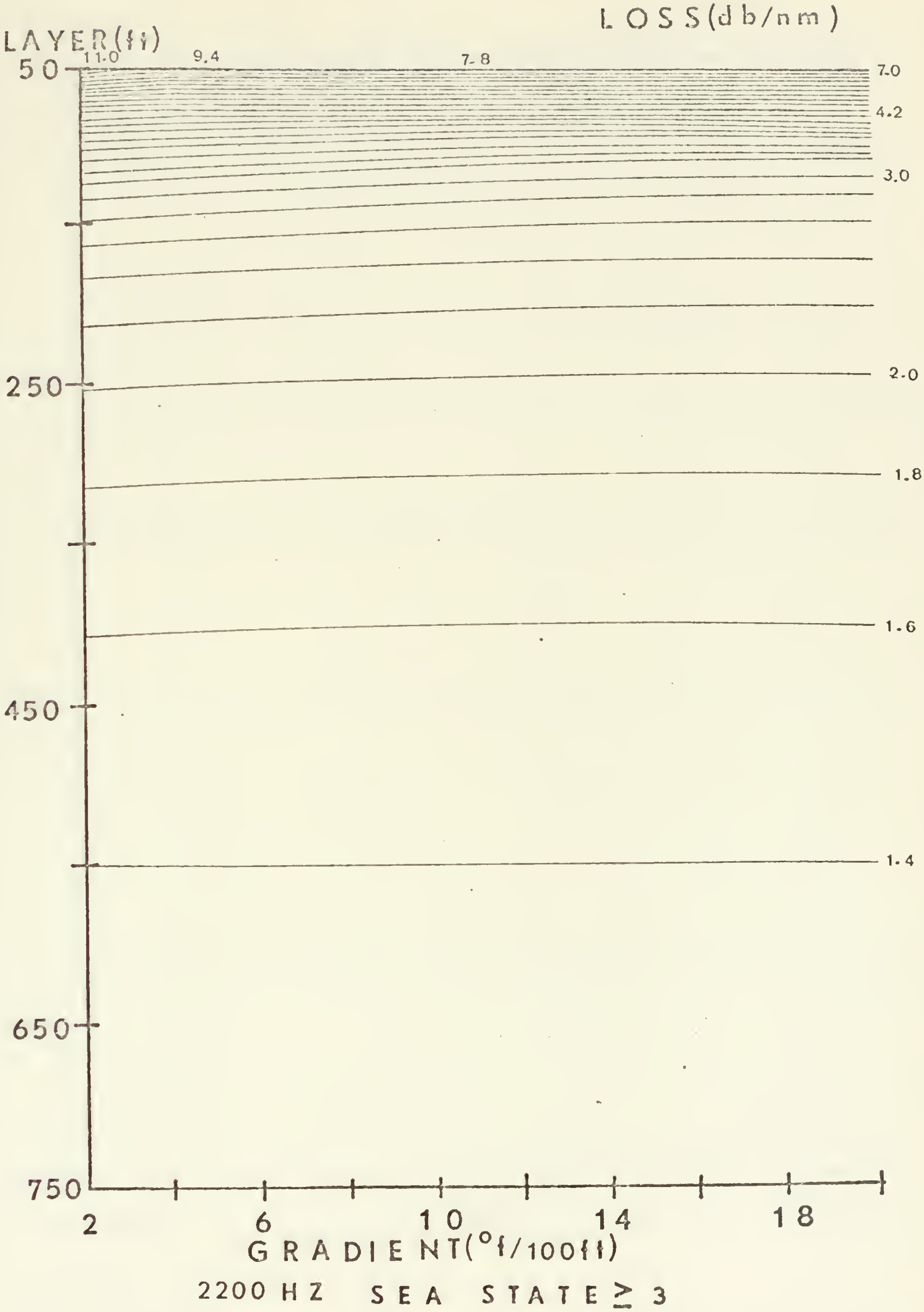


Figure A-41. Iso-loss contours for 2200 HZ and high sea state.

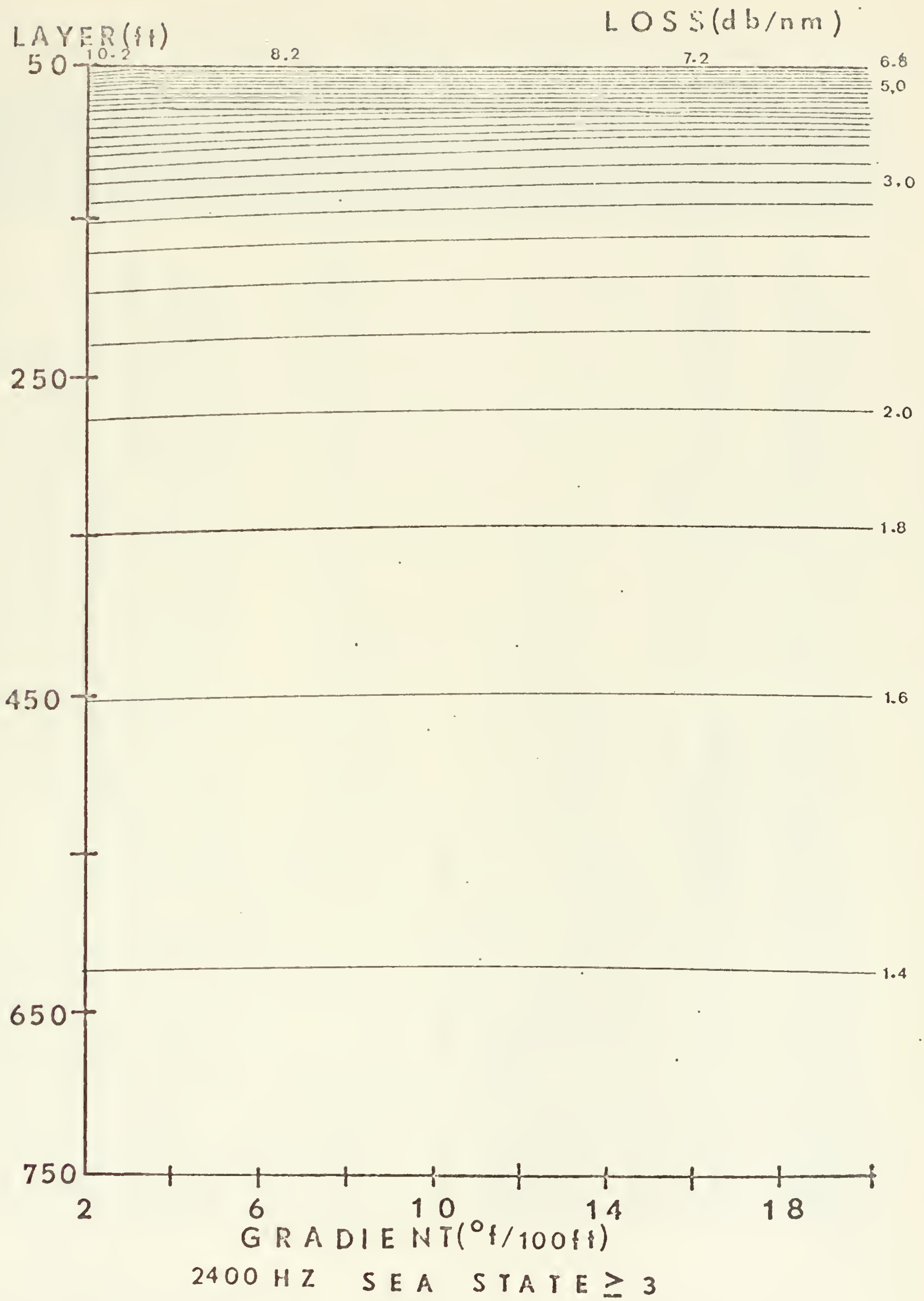


Figure A-42. Iso-loss contours for 2400 HZ and high sea state.

```
C
C
C     DUCT LOSS PROGRAM
C
C
C     THIS PROGRAM COMPUTES THE LOSSES IN A SURFACE DUCT DUE TO
C
C     SIGNAL ATTENUATION.  THE EQUATIONS UTILIZED ARE: (1) LEAKAGE
C
C     TERM FROM AN APPROXIMATION TO NORMAL MODE (2)  SCATTERING TERM
C
C     FROM EMPIRICAL DATA AND (3) AN ABSORBTION TERM FROM EMPIRICAL
C
C     DATA.  THE LIMITING DOMAINS OF THE GOVERNING PARAMETERS ARE:
C
C     FREQUENCY: 100-2400 HZ
C
C     LAYER DEPTH: 50 TO 750 FT
C
C     BELOW LAYER THERMAL GRADIENT: -2 DEG.F/100 FT TO -20 DEG.F/100 FT
C
C     SEA STATE: LESS THAN 3 OR GREATER THAN 3
C
C
C
C     DIMENSION REQUIRED ARRAYS
C
      REAL*8 TITLE(12),TITL1(12)
      REAL*4 LABEL/'    '/
      LOGICAL*1 LTG(3)/.TRUE.,.TRUE.,.FALSE./
      DIMENSION CL1(50)
      DIMENSION ALOSS(29.10),ALD(25),AGR(20),AFQ(24)
      DIMENSION ALOS1(29,10,24),ALOS2(24)
C
C     EQUATION FOR LOW FREQUENCY CUTOFF
      F1(ALX)=1.08E06/ALX**1.5
C
C     EQUATION FOR LEAKAGE. ABSORBTION, AND SCATTERING
C     FREQUENCY LESS THAN 1000 HZ
      FLOSS(F,G.H,SC,CLC)=14.88E05*(F**(-5.0/3.0)*G**(-1.0/3.0)*H**(-3.0
     1))+(1.0/8.0)*F**2+SC*SQRT(F/H)+CLC
C
C     EQUATION FOR LEAKAGE, ABSORBTION, AND SCATTERING.
C     FREQUENCY GREATER THAN 1000 HZ
      FLOSH(FH,GH,HH,SCH,CLCH)=14.88E05*(FH**(-5.0/3.0)*GH**(-1.0/3.0)
     1*HH**(-3.0))+2.0*FH**2*(0.1/(1.0+FH**2)+40.0/(4100.0+FH**2))
     2+SCH*SQRT(FH/HH)+CLCH
      CL=0.0
```

```
      ASCT=0.0                                                          DCT00510
C                                                                       DCT00520
C      LAYER DEPTH LOOP INDEX                                           DCT00530
C                                                                       DCT00540
      DO  1099  NL=1,50                                                 DCT00550
      CL1(NL)=0.2*FLOAT(NL)                                             DCT00560
 1099  CONTINUE                                                         DCT00570
C                                                                       DCT00580
C      SET ARGUEMENTS FOR SUBROUTINES CONTUR AND DRAW                   DCT00590
C                                                                       DCT00600
      IW=5                                                              DCT00610
      IH=7                                                              DCT00620
      IWIDE=5                                                           DCT00630
      IHIGH=8                                                           DCT00640
      MDYAX=0                                                           DCT00650
      MDXAX=0                                                           DCT00660
      IYRT=0                                                            DCT00670
      IXUP=0                                                            DCT00680
      YSCL=0.8                                                          DCT00690
      EXSC=5.0E02                                                       DCT00700
      IGRID=0                                                           DCT00710
      ITYPE=0                                                           DCT00720
C      READ TITLES FOR PLOTS                                            DCT00730
C                                                                       DCT00740
      READ(5,9095)(TITL1(I),I=1,6)                                      DCT00750
      READ(5,9095)(TITLE(I),I=1,6)                                      DCT00760
C      SEA STATE ITERATION LOOP                                         DCT00770
C                                                                       DCT00780
      DO  6999  LB=1,2                                                  DCT00790
      ASCT=ASCT+9.0                                                     DCT00800
      K1=0                                                              DCT00810
C                                                                       DCT00820
C      FREQUENCY ITERATION LOOP                                         DCT00830
      DO  3999  K=100,2400,100                                          DCT00840
      READ(5,9095)(TITL1(I),I=7,12)                                     DCT00850
 9095  FORMAT(6A8)                                                      DCT00860
      K1=K1+1                                                           DCT00870
      AFQ(K1)=FLOAT(K)                                                  DCT00880
      AF=FLOAT(K)*1.0E-03                                               DCT00890
C                                                                       DCT00891
C      PRINT OUTPUT TABLE HEADINGS IN FORMAT INDICATED                  DCT00892
C                                                                       DCT00893
      WRITE(6,3006) K                                                   DCT00894
      WRITE(6,5010)                                                     DCT00895
      IF(ASCT.LT.10.0) GO TO 3004                                       DCT00896
      WRITE(6,4006)                                                     DCT00897
      GO TO 3007                                                        DCT00898
 3004  WRITE(6,4005)                                                    DCT00899
```

```
 3007  N=0
       WRITE(6,5006)
C
C       LAYER DEPTH ITERATICN LOOP
C
       DO  2999  J=50,750,25
       N=N+1
       M=0
C
C       BELOW LAYER GRADIENT ITERATION LOOP
C
       DO  2998  I=2,20,2
       M=M+1
       ALD(N)=FLOAT(J)
       GR=5.842E-02*FLOAT(I) -0.018
C
C       LOGIC FOR FREQUENCY GREATER THAN 1000 HZ, USE
C       ALTERNATE FORMULA
C
       IF(K.GT.1000) GO TO 3009
C
C
C       COMPUTE DUCT LOSS AND STORE IN ARRAY POSITION FCR
C       LATER USE IN PRINTOUT AND CONTOUR ROUTINES
C
       ALOS1(N,M,K1)=FLOSS(AF,GR,ALD(N),ASCT,CL)
       ALOSS(N,M)=ALOS1(N,M,K1)
       IF(K.LE.1000) GO TO 3019
 3009    ALOS1(N,M,K1)=FLOSH(AF,GR,ALD(N),ASCT,CL)
       ALOSS(N,M)=ALOS1(N,M,K1)
 3019  AFH=FLOAT(K)
C
C       SET VARIABLE F2 FOR LOWER LIMIT TCLERANCE OF 70 PERCENT
C       LOW FREQUENCY CUTOFF
C
       F2=0.7*F1(ALD(N))
C       SET POINTS OUTSIDE TOLERANCE EQUAL TO 6.0 DB/NM
C       TO FACILITATE PLOTTING IN SUBROUTINE CONTUR
C
       IF(AFH.LT.F2) ALOS1(N,M,K1)=6.0
C
C       SET POINTS OUTSIDE TOLERANCE LIMIT EQUAL TO A VALUE
C       GREATER THAN THE ALLOCATED FIELD WIDTH IN THE OUTPUT PRINT
C       ROUTINE.  RESULT IS **** PRINTED FOR THESE VALUES.
C
       IF(AFH.LT.F2) ALOSS(N,M)=999.9
 2998   CONTINUE
C
```

```
C       PRINT OUTPUT TABLES IN FORMAT INDICZTED                          DCT01352
C                                                                        DCT01353
      WRITE(6,2005) ALD(N),(ALOSS(N,KK),KK=1,15)
 2999  CONTINUE                                                          DCT01360
      CALL CONTUR(ALOSS,29,10,29,CL1,NL,TITL1,IW,IH,LTG)                 DCT01370
 3999  CONTINUE                                                          DCT01380
C                                                                        DCT01390
C       LOOPS WHICH FOLLOW TRANSFER LOSS VALUES TO DIFFERENT ARRAYS      DCT01400
C       AND FORMATS FOR USE IN SUBROUTINE DRAW.                          DCT01410
C                                                                        DCT01420
      DO  5999  NG=3,9,3                                                 DCT01430
 9092 READ(5,9095)(TITLE(I),I=7,12)                                      DCT01440
      DO  5999  NL=3,27,4                                                DCT01450
      DO  4999  NF=1,24                                                  DCT01460
      ALOS2(NF)=ALOS1(NL,NG,NF)                                          DCT01470
 4999  CONTINUE                                                          DCT01480
      NC=2                                                               DCT01490
      IF(NL.EQ.3) NC=1                                                   DCT01500
      IF(NL.EQ.27) NC=3                                                  DCT01510
      CALL DRAW(24,AFQ,ALOS2,NC,ITYPE,LABEL,TITLE,EXSC,YSCL,IXUP,IYRT,   DCT01520
     1MDXAX,MDYAX,IWIDE,IHIGH,IGRID,LAST)                                DCT01530
 5999  CONTINUE                                                          DCT01540
 6999  CONTINUE                                                          DCT01550
C                                                                        DCT01560
C       FORMAT STATEMENTS FOR PRINT OUTPUT                               DCT01570
C                                                                        DCT01580
C                                                                        DCT01590
 2005  FORMAT('0',T23,F5.1,T30,10(F4.1,1X))                              DCT01600
 3006  FORMAT('1',/////,T40,'PROPAGATION LOSS IN DB/NM FOR ',I4,' HZ'/ )DCT01610
 4005  FORMAT('0',T45,'SEA STATE :   LESS THAN 3'/'0',T20,'LAYER(FT)',   DCT01620
     1T45,'BELOW LAYER GRADIENT(DEG.F/100FT.)')                          DCT01630
 4006  FORMAT('0',T45,'SEA STATE :GREATER THAN 3'/'0',T20,'LAYER(FT)',   DCT01640
     1T45,'BELOW LAYER GRADIENT(DEG.F/100FT.)')                          DCT01650
 5006  FORMAT('0',T30,'2.0  4.0  6.0  8.0  10.0 12.0 14.0 16.0 18.0 20.0DCT01660
     1 '//)                                                              DCT01670
 5010  FORMAT('0',T45,'***: NON-DUCTED CASE')                            DCT01680
      STOP                                                               DCT01690
      END                                                                DCT01700
```

```fortran
C               SPREADING PROGRAM
C
C
C        THIS PROGRAM CALCULATED SPREADING LOSSES AND OUTPUTS TABLES AND
C        GRAPHS OF THE RESULTS.
C
C
C        THE EQUATIONS UTILIZED ARE: (1) CYLINDRICAL SPREADING (2) SPH-
C        ERICAL SPREADING (3) TRANSITION RANGE SPREADING(EFFECTIVE LAYER
C        LOSS).
C
C
C
C        DIMENSION REQUIRED ARRAYS
C
      REAL*8 TITLE(6)
      REAL*8 TITLE1(6)
      REAL*8 TITLE2(6)
        REAL*8 TITLE3(6)
      DIMENSION GRA(100),CRS(100),ALOSP(100)
      DIMENSION R(100),ALOS(100),ACOR(30),ALD(500),FCO(30)
C
C      CYLINDRICAL SPREADING EQUATION
C
      FSPD(R)=10.0*ALOG10(R)+33.0
C
C      SPHERICAL SPREADING EQUATION
C
      FSPD2(R)=20.0*ALOG10(R)+66.0
C
C      LOW FREQUENCY CUTOFF EQUATION
C
      FCOF(SLD)=1.08E06/SLD**(1.5)
C
C      READ TITLES FOR PLOTS
C
      READ(5,1000)TITLE
      READ(5,1000)TITLE1
      READ(5,1000) TITLE2
      READ(5,1000) TITLE3
 1000  FORMAT(6A8)
      DO  9099  IA=1,2
C
C      RANGE LOOP
C
      DO  1099  I=1,100
      AR=0.5*FLOAT(I)
      ALOS(I)=FSPD(AR)
```

```
      ALOSP(I)=FSPD2(AR)
      R(I)=AR
 1099 CONTINUE
      N=0
C
C      SET PRESSURE GRADIENT TERM
C
      GR=0.018
C
C      LAYER DEPTH ITERATICN LOOP
C
      DO  2099  I=50,750,25
      N=N+1
      ALD(N)=FLOAT(I)
      SLD=ALD(N)
      FCO(N)=FCOF(SLD)
C
C      COMPUTE RADIUS OF CURVATURE
C
      RAD=1666.6/GR
C
C      COMPUTE TRANSITION RANGE
C
      RO=SQRT(ALD(N)/6.0*RAD)
C
C      COMPUTE EFFECTIVE LAYER (TRANSITION RANGE) LOSS
C
      ACOR(N)=10.0*ALOG10(RO)
 2099 CONTINUE
 2199 CONTINUE
C
C      PRINT OUTPUT IN FORMATS INDICATED
C
      WRITE(6,8008)
 8008 FORMAT('1',T15,'FREQUENCY CUT-OFF AND EFFECTIVE LAYER CORRECTION'
     1//)
      WRITE(6,1002)
 1002 FORMAT('0',T10,'LAYER(FT)',3X,'CUT-OFF FREQUENCY(HZ)',3X,
     1'EFFECTIVE LAYER LOSS(DB)'/)
      DO  2999  N=1,29
      WRITE(6,1003) ALD(N),FCO(N),ACOR(N)
 1003 FORMAT('0',T10,F5.1,T30,F7.1,T55,F4.1)
 2999 CONTINUE
      WRITE(6,1009)
C
C      OUTPUT PLOTS USING SUBROUTINE PLOTP
C
      CALL PLOTP(ACOR,ALD,29,0)
```

```
      WRITE(6,1009)
      CALL  PLOTP(R,ALOS,100,0)
      WRITE(6,1001) TITLE
      WRITE(6,1009)
      CALL  PLOTP(R,ALOSP,100,0)
      WRITE(6,1001) TITLE2
      WRITE(6,1009)
      CALL  PLOTP(GRA,CRS,100.0)
      WRITE(6,1001) TITLE3
      WRITE(6,1005)
1005  FORMAT('1',T25,'SPREADING LOSS/DUCTED CASES'//'0',T25,'RANGE(NM)
     1     LOSS(DB) '//'0',5('RANGE  LOSS  ')//)
      DO  3999  I=2,20,2
       N1= I+20
      N2=N1+20
      N3=N2+20
      N4=N3+20
      WRITE(6,1006) R(I),ALOS(I),R(N1),ALOS(N1),R(N2),ALOS(N2),R(N3),
     1ALOS(N3),R(N4),ALOS(N4)
1006  FORMAT('0',5(F4.1,2X,F5.1,2X))
3999  CONTINUE
      WRITE(6,1008)
1008  FORMAT('1',T20,'    SPREADING   LOSS  /   NON-DUCTED CASES'//
     1'0',T25,'RANGE(NM)        LOSS(DB) '//
     2'0',5('RANGE  LOSS  '))
      DO  4999  I=2,20,2
       N1= I+20
      N2=N1+20
      N3=N2+20
      N4=N3+20
      WRITE(6,1006) R(I),ALOSP(I),R(N1),ALOSP(N1),R(N2),ALOSP(N2),R(N3),
     1ALOSP(N3),R(N4),ALOSP(N4)
4999  CONTINUE
8088  CONTINUE
9099  CONTINUE
1001  FORMAT('0',T20,6A8)
1009  FORMAT('1')
      STOP
      END
```

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3. ABSTRACT

An acoustic model for low frequency (100-2400 HZ) propagation loss within a surface duct is examined. An analysis of the sensitivity of this model as a function of the governing environmental parameters is performed. The results of this analysis show that the frequency and mixed layer depth are influential over a wide range of environmental conditions and that the below layer thermal gradient becomes important at low frequencies when the layer depth is relatively shallow. Under certain conditions, a change in below layer thermal gradient of 2°F/100 FT has the same resultant effect as a 25 FT change in the mixed layer depth. The results of this analysis are then utilized to develop a correction algorithm which can be employed to update propagation loss forecasts (issued by Fleet Numerical Weather Central, Monterey) when required due to changing environmental conditions.

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